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In This Issue

Change and continuity mark this issue of *Agricultural Economics Research.* After 7 successful years as economics editor of the journal, Clark Edwards requested an assignment that would substitute doing research for reviewing research. While the community engaged in agricultural economics research will respect his desire, it will regret the corollary that he now has less time to help others. Fortunately, he has agreed to remain a member of the editorial board, so his accumulated experience will still help guide the journal.

My own goal, as the new editor, will be to maintain the quality of the journal and to enlarge the community of contributors and reviewers. I encourage more of those researchers in the Economic Research Service (ERS) and Statistical Reporting Service who have not submitted articles in recent years to do so. While these two groups have traditionally submitted most of the articles to the journal and they also contain a large proportion of potential authors, we continue to welcome articles from any authors reporting U.S. Department of Agriculture (USDA) supported research in agricultural economics and related disciplines.

Through this change of editorship, as in the past with all preceding changes, our purpose continues to be that stated in Volume 1, Number 1 (January 1949), by O. V. Wells. The journal publishes articles (1) reporting results of economic research supported by USDA, (2) describing new methods or critically evaluating old methods still in use, and (3) describing new or expanding areas of research or statistics. Book reviews are included now as then. In 1976, following a complete review of the purpose and performance of the journal, the same purpose was restated by J. B. Penn (January 1976). Only one addition to the types of articles has appeared. Following the 1975/76 review, the journal introduced research reviews—shorter, sometimes less rigorous pieces with the same subject areas as the major articles.

In 1983, 34 years after its first statement, the original purpose is still the proper one. The content of agricultural economics research has changed, of course, but the need remains to report it, to constantly expand and scrutinize its methods, and to identify new and expanding directions.

The use of new methods, which have become highly technical, does not mean discarding the older methods, which can include logical writing. The journal welcomes submissions using the full range of methods employed in agricultural economics, associated areas of statistics, and related areas of social science, as it has for 34 years.

The first two articles in this issue relate to the first and most important purpose of the journal, reporting research results. These articles report research conducted jointly by investigators in ERS and the land-grant universities.

Collins and Taylor develop a model of crop production and sales designed to reflect the effects of change, particularly technical change. The model user changes yields, for example, to trace the effects of a new pesticide. The design of the model makes possible the easy use of expert opinion. Its design is such that a user can employ it to ask "what if?" questions easily. To evaluate and use the results appropriately, however, the user needs to understand the model's construction. The model differs from others in two ways: (1) demand for inputs is estimated directly from relative returns (the "duality" approach) rather than from a mathematical representation of the production process, and (2) benefits or costs resulting from a change are calculated separately for consumers and producers.

Taylor and his associates employ the model developed by Collins and Taylor to evaluate alternative approaches to boll weevil control and eradication. Because the model is designed to incorporate judgment, the evaluation could use expert opinion to develop estimates of yield changes. The authors estimate effects of different pest control methods using Delphi, a process which polls an expert panel, gives each member a description of the range of

group responses, and then polls again. The combination of expert opinion and a comprehensive model illustrates the value of both. Although the reader's immediate response to boll weevil eradication might be that it would help cotton farmers as a group, the result indicates that the consequent higher yields would reduce incomes for cotton farmers as a group, while raising incomes of farmers in heavily infested areas.

In the third article, Willard Cochrane returns to the pages of this journal in a rare kind of article, one of organizational reflection and purpose. In the history of the journal, a handful of such articles have appeared, including Professor Cochrane's article announcing the formation of ERS in 1961 and the two articles already mentioned examining the purpose and performance of the journal. In this issue, he identifies the proper role of ERS as that of a staff agency to the Nation, which means timely and appropriate responses to the Secretary of Agriculture, the Congress, and the interested public—including farmers, farm groups, agribusiness, trade associations, food and nutrition organizations, and religious and educational institutions. He concludes that ERS has done well, but could do better, and that its future depends on commitment by its leadership and professional staff to do good staff work for the Agency's clientele.

Lorna Aldrich

Contents

TECHSIM: A Regional Field Crop and National Livestock Econometric Simulation Model

By Glenn S. Collins and C. Robert Taylor*

Abstract

TECHSIM, a regional field crop and national livestock econometric simulation model, evaluates impacts of technological change. Unlike other econometric models specified and constructed in an *ad hoc* fashion, TECHSIM makes practical use of theory by incorporating *a priori* information regarding the structure of the agricultural sectors modeled during estimation. This procedure improves calculation of welfare gains or losses resulting from technological changes to agriculture. The model provides policymakers with detailed welfare answers; users need only supply changes in yields and variable production costs.

Keywords

Field crop sector, livestock sector, econometric model, simulation, welfare impacts

TECHSIM[1] is a relatively simple user-oriented econometric simulation model that can be used to evaluate the shortrun effects of a broad range of technological changes on markets for major field crops and livestock products.[2] Unlike other econometric simulation models, which are structured primarily in an *ad hoc* fashion, TECHSIM's structure draws heavily on comparative static relationships and on welfare and microeconomic theory; in particular, homogeneity and symmetry restrictions were imposed on estimates of the model. The production component of the model was based on the premise that producers make planting or livestock production decisions by comparing expected net returns of production options. Such a net return specification allows supply shifts resulting from changes in yield and variable production costs to be logically derived, and it provides a recursive link that allows the model to be simulated through time. Imposition of theoretical restrictions allows computation of welfare results that are consistent with theoretical results specified by Chavas and Collins (*3*) for technological changes and with those presented by Just and Hueth (*7*) for price distortions.[3] Hence, the model provides policymakers with detailed welfare answers; users need only supply changes in yields and variable production costs.

Overview of the Model

Because of the regional heterogeneity of U.S. crop production practices, we separated the field crop sector into 13 producing regions (see figure). The field crop commodities included in the model (but not for all regions) are corn, grain sorghum, soybeans, cotton lint, cottonseed, wheat, barley, and oats. We aggregated the last three crops into a small grain category. The model contains the forward meal and oil products of cottonseed and soybeans. The livestock sector is national and includes fed beef, nonfed beef, pork, and sheep.

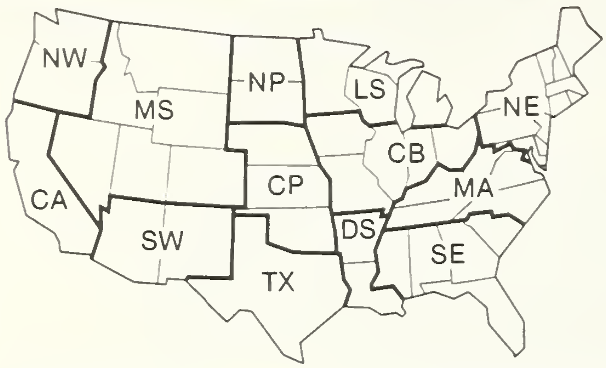
*Collins is an assistant professor in the Department of Agricultural Economics at Texas A&M University and Taylor is a professor in the Department of Agricultural Economics and Economics at Montana State University. Technical article 18315 of the Texas Agricultural Experiment Station.

[1]The TECHSIM model and consultative input by its developers are currently made available to the Economic Research Service through Cooperative Research Agreement No. 58-319V-2-00349 between the U.S. Department of Agriculture (USDA) and Montana State University. The refinement and application of TECHSIM for evaluation of alternative Federal-State boll weevil/cotton insect management programs was funded through Cooperative Research Agreement No. 58-319V-8-2530X between USDA and Texas A&M University and is reported in the second article in this issue. An earlier version of the model (AGSIM) was developed under Environmental Protection Agency contract No. 68-01-5041.

[2]Technological change in this article refers to any change in the technical parameters of the firm's production function as well as any change in institutional constraints.

[3]Italicized numbers in parentheses refer to items in the References at the end of this article.

Production Regions Within TECHSIM



CA = California	MS = Mountain States
CB = Corn Belt	NE = Northeast
CP = Central Plains	NP = Northern Plains
DS = Delta States	NW = Northwest
LS = Lake States	SE = Southeast
MA = Mountainous Appalachian	SW = Southwest
	TX = Texas

Technological change is introduced by changing one or more of the exogenous variables listed in tables 1 and 2. Technological change may take the form of pesticide withdrawal policies, change in farm size, or introduction of new varieties of field crops and improved livestock breeds. For example, one can initiate simulation of a pesticide withdrawal on the field crop sector by changing per-acre yield or variable production costs for a crop either in a specified region or a set of regions. Changes in livestock are made by changing liveweight yields or livestock variable production costs at slaughter. One can simulate technological changes resulting from institutional changes by changing policy variables such as exports, imports, or loan rates.

The simulation model traces the effects of these changes on production, price, utilization, farm rents, and producer and consumer welfare. For the major field crops, the model estimates regional planted acreage, yield, production, producer net returns, and variable production costs. It provides aggregate estimates on total supplies, prices, domestic demands,

Table 1—TECHSIM: Endogenous and exogenous variables of the field crop sector

Variable	Definition[1]
Endogenous:	
AC_i	Corn harvested acreage, region i, 1,000 acres
AG_i	Small grains planted acreage, region i, 1,000 acres
AGS_i	Grain sorghum harvested acreage, region i, 1,000 acres
ACT_i	Cotton planted acreage, region i, 1,000 acres
AS_i	Soybean planted acreage, region i, 1,000 acres
NRC_i	Net returns per harvested acre of corn, region i, dollars per acre
$NRGS_i$	Net returns per planted acre of small grains, region i, dollars per acre
$NRCT_i$	Net returns per harvested acre of grain sorghum, region i, dollars per acre
NRS_i	Net returns per planted acre of soybeans, region i, dollars per acre
AC	Corn harvested acreage, United States, 1,000 acres
AG	Small grains planted acreage, United States, 1,000 acres
AGS	Grain sorghum harvested acreage, United States, 1,000 acres
ACT	Cotton planted acreage, United States, 1,000 acres
AS	Soybeans planted acreage, United States, 1,000 acres
PC	Price of corn received by farmers, United States, cents per pound
CP	Corn production, United States, million pounds
CFDD	Corn food demand, United States, million pounds
CFD	Corn feed demand, United States, million pounds
CSD	Corn seed demand, United States, million pounds
CPSD	Corn private stock demand, United States, million pounds
CED	Corn net export demand, United States, million pounds

—Continued

Table 1—TECHSIM: Endogenous and exogenous variables of the field crop sector (Continued)

Variable	Definition[1]
Endogenous:	
PG	Weighted price of small grains, United States, cents per pound
GP	Small grains production, United States, million pounds
GFDD	Small grains food demand, United States, million pounds
GFD	Small grains feed demand, United States, million pounds
GSD	Small grains seed demand, United States, million pounds
GPS	Small grains private stock demand, United States, million pounds
GED	Small grains net export demand, United States, million pounds
GSP	Grain sorghum production, United States, million pounds
PGS	Price of grain sorghum received by farmers, United States, cents per pound
GSFDD	Grain sorghum food demand, United States, million pounds
GSFD	Grain sorghum feed demand, United States, million pounds
GSSD	Grain sorghum seed demand, United States, million pounds
GSPSD	Grain sorghum private stock demand, United States, million pounds
GSED	Grain sorghum net export demand, United States, million pounds
CTP	Cotton production, United States, million pounds
PCTL	Price of cotton lint received by farmers, United States, cents per pound
CTLMD	Cotton lint mill demand, United States, million pounds
CTLED	Cotton lint net export demand, United States, million pounds
CTLPSD	Cotton lint private stock demand, United States, million pounds
CTSP	Cottonseed production, United States, million pounds
PCTS	Price of cottonseed received by farmers, United States, cents per pound
CTSCD	Cottonseed crushing demand, United States, million pounds
CTSSD	Cottonseed seed demand, United States, million pounds
CTSPSD	Cottonseed private stock demand, United States, million pounds
CTSED	Cottonseed net export demand, United States, million pounds
SBP	Soybean production, United States, million pounds
PSB	Price of soybeans received by farmers, United States, cents per pound
SBCD	Soybean crushing demand, United States, million pounds
SBSD	Soybean seed demand, United States, million pounds
SBPSD	Soybean private stock demand, United States, million pounds
SBED	Soybean net export demand, United States, million pounds
CTSMP	Cottonseed meal production, United States, million pounds
PCTSM	Price of cottonseed meal, 41 percent, Memphis, cents per pound
CTSMFD	Cottonseed meal feed demand, United States, million pounds
CTSMPSD	Cottonseed meal private stock demand, United States, million pounds
CTSMED	Cottonseed meal net export demand, United States, million pounds
CTSOP	Cottonseed oil production, United States, million pounds
PCTSO	Price of cottonseed oil, f.o.b. Valley Points, cents per pound
CTSOFD	Cottonseed oil food demand, United States, million pounds
CTSOPSD	Cottonseed oil private stock demand, United States, million pounds
CTSOED	Cottonseed oil net export demand, United States, million pounds
SBMP	Soybean meal production, United States, million pounds
PSBM	Price of soybean meal, 44 percent, Decatur, cents per pound
SBMFD	Soybean meal feed demand, United States, million pounds
SBMPSD	Soybean meal private stock demand, United States, million pounds

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Table 1—TECHSIM: Endogenous and exogenous variables of the field crop sector (Continued)

Variable	Definition[1]
Endogenous:	
SBMED	Soybean meal net export demand, United States, million pounds
SBOP	Soybean oil production, United States, million pounds
PSBO	Price of soybean oil, crude tanks, Midwestern mills, cents per pound
SBOFDD	Soybean oil food demand, United States, million pounds
SBOPSD	Soybean oil private stock demand, United States, million pounds
SBOED	Soybean oil net export demand, United States, million pounds
Exogenous:	
$VPCC_i$	Corn variable production costs, region i, dollars per acre
$VPCG_i$	Small grains weighted variable production costs, region i, dollars per acre
$VPCGS_i$	Grain sorghum variable production costs, region i, dollars per acre
$VPCCT_i$	Cotton variable production costs, region i, dollars per acre
$VPCS_i$	Soybean variable production costs, region i, dollars per acre
YC_i	Corn yield per harvested acre, region i, pounds per acre
YG_i	Small grains weighted yield per planted acre, region i, pounds per acre
YGS_i	Grain sorghum yield per harvested acre, region i, pounds per acre
$YCTl_i$	Cotton lint yield per planted acre, region i, pounds per acre
$YCTS_i$	Cottonseed yield per planted acre, region i, pounds per acre
YS_i	Soybean yield per planted acre, region i, pounds per acre
PPl	Prices paid index for production items, interest, and wage rates (1967=100)
CTSMYC	Cottonseed meal crushing yield coefficient, percent
CTSOYC	Cottonseed oil crushing yield coefficient, percent
SBMYC	Soybean meal crushing yield coefficient, percent
SBOYC	Soybean oil crushing yield coefficient, percent
T	Time trend, 1961=61, 1962=62, . . . , 1977=77
EXP	Expenditures on nonfood items, United States, million dollars
Dl	Dummy variable 1974=1, 0 otherwise
POLY	Price of rayon polyester, United States, cents per pound
PFCT	Price of cotton lint at foreign markets, cents per pound
WCTS	World cotton lint supply excluding United States, million pounds
CTLR	Cotton loan rate, United States, cents per pound
SBGS	Soybean Government stocks, United States, million pounds
PFM	Price of fish meal at foreign export markets, Brazil, cents per pound
SBOPL	Soybean oil exports P.L. 480, million pounds
CTSOPL	Cottonseed oil exports P.L. 480, million pounds
POP	Population, United States, million

[1]All value variables were deflated by the producer price index.

Table 2—TECHSIM: Endogenous and exogenous variables of the livestock sector

Variable	Definition[1]
Endogenous:	
CPOF	Cattle placed on feed, million head
FBPP	Fed beef production, liveweight, million pounds
FBP	Fed beef production, carcass weight, million pounds
PFFB	Price of fed steers, Omaha, cents per pound
PRFB	Price of retail choice cuts of beef, cents per pound
NRFB	Fed beef net returns = (PFFB — VPCFB) * ASWFB, cents per head
FBDD	Fed beef domestic demand, million pounds
RCI	Cattle not placed on feed, million head
NFBPP	Nonfed beef production, liveweight, million pounds
NFBP	Nonfed beef production, carcass weight, million pounds
PFNFB	Price of cull cows at Omaha, cents per pound
PRNFB	Price of retail hamburger, cents per pound
NRNFB	Nonfed beef net returns = (PFNFB — VPCNFB) * ASWNFB, cents per head
NFBI	Nonfed beef imports, million pounds
NFBDD	Nonfed beef domestic demand, million pounds
NFBSD	Nonfed beef stock demand, million pounds
NFBED	Nonfed beef export demand, million pounds
SFAR	Sow farrowings, million head
POF	Pigs on feed, million head
PPP	Pork production, liveweight, million pounds
PP	Pork production, carcass weight, million pounds
PFP	Price of barrows and gilts, cents per pound
PRP	Price of retail pork, cents per pound
NRP	Pork net returns = (PFP — VPCP) * ASWP, cents per head
PI	Pork imports, million pounds
PDD	Pork domestic demand, million pounds
PSD	Pork stock demand, million pounds
PED	Pork export demand, million pounds
SBHI	Sheep breeding herd inventory, million pounds
SPOF	Sheep on feed, million head
SPP	Sheep production, liveweight, million pounds
SP	Sheep production, carcass weight, million pounds
PFL	Price of farm lambs, cents per pound
PRL	Price of retail mutton, cents per pound
NRL	Lamb net returns = (PFL — VPCL) * ASWL, cents per head
NSI	Sheep net imports (imports-exports), million pounds
SDD	Sheep domestic demand, million pounds
SSD	Sheep stock demand, million pounds
WPL	Weighted price of livestock by production, cents per pound
WPF	Weighted price of feed (grains and meals) by production, cents per pound
I	Income spent on fed beef, nonfed beef, pork and sheep, million dollars

—Continued

Table 2—TECHSIM: Endogenous and exogenous variables of the livestock sector (Continued)

Variable	Definition[1]
Exogenous:	
ASWFB	Fed beef average liveweight at slaughter, pounds
ASWNFB	Nonfed beef average liveweight at slaughter, pounds
ASWP	Pork average liveweight at slaughter, pounds
ASWL	Lamb average liveweight at slaughter, pounds
VPCFB	Fed beef variable production costs at slaughter, cents per pound
VPCNFB	Nonfed beef variable production costs at slaughter, cents per pound
VPCP	Pork variable production costs at slaughter, cents per pound
VPCL	Lamb variable production costs at slaughter, cents per pound
PPLIT	Pigs per litter, head
FLPI	Personal consumption expenditures in importing countries, million dollars

[1]All value variables were deflated by the producer price index.

exports, ending stocks, producer net returns, and welfare measures for all field crops. For livestock, the model provides aggregate estimates on inventories, the number of animals on feed or placed on feed, slaughter (liveweight and carcass), imports, total supplies, domestic demands, exports, ending stocks, farm prices, retail prices, price margins, and welfare measures for each livestock group. These results are obtained by simultaneously solving all markets for the equilibrium price vector.

Structure of the Production and Consumption Sectors

In both the field crop and livestock production sectors, we use expected net returns as the principal explanatory variables rather than commodity prices. For both production sectors, this implies that producers who maximize farm income allocate production between enterprises based on expected net returns, rather than simply on output and input prices.

Table 3 shows the general structure of the production and consumption sectors in TECHSIM. It depicts the assumed objective function, the resulting behavioral choice equations, the comparative static results, and the functional form of the estimated equations for each production and consumption component. For example, one can obtain regional planted acreage equations by maximizing:

$$\Pi = \Sigma_i^n \pi_i A_i + \lambda[A_T - \Sigma_i^n A_i] \qquad (1)$$

where Π is regional farm profit, π_i is expected regional net returns for field crops grown in the region, A_i is planted acreage, and A_T is the total cropland which can be allocated among crop alternatives. Maximization of equation (1) gives behavioral choice equations for field crop producers as follows:[4]

$$A_i = A_i^* (\pi_1, \ldots, \pi_n, A_T) \quad \text{for all i} \qquad (2)$$

We obtained comparative static results on the theoretical implications of equation (1) by minimizing the difference between the indirect and direct profit functions:[5]

$$L^* = \Pi^* - \Pi \qquad (3)$$

where II* and II are the indirect and direct profit functions, respectively. Minimization of equation (3) results in the following theoretical implications (see appendix):

[4]From equation (2), the firm is assumed to allocate acreage based on the relative expected per-acre net returns of the firm's crop alternatives. This assumption appears reasonable as planted acreage is fixed after planting decisions have been made. However, one would expect that both yields and inputs could be altered if harvested acreage equations were desired, as the firm could adjust input usage during the production period preceding harvest. In this case, harvested acreage equations would be a function of output and input prices rather than of net returns.

[5]The direct and indirect profit functions have conventional meanings where the indirect profit function contains parameters only as arguments (that is, optimal quantities of A_i^* are inserted into the direct profit function).

Table 3—General structure of the production and consumption sectors in TECHSIM

Sector	Objective function	Behavioral function	Functional form[1]	Theoretical implications	
				Own effect	Symmetry
Field crop:					
Regional farm acreage[2]	$\Pi = \Sigma_i^n \pi_i A_i + \lambda[A_T - \Sigma_i^n A_i]$	$A_i^* (\pi_1, \ldots, \pi_n, A_T)$	GL	$\partial A_i^*/\partial \pi_i \geqslant 0$	$\partial A_i^*/\partial \pi_j = \partial A_j^*/\partial \pi_i$
U.S. processors' supply and demand[3]	$\Pi = \Sigma_i^n r_i Q_i + \lambda F(Q)$	$Q_i^* (r_1, \ldots, r_n)$	GL and LOG	$\partial Q_i^*/\partial r_i \geqslant 0$	$\partial Q_i^*/\partial r_j = \partial Q_j^*/\partial r_i$
Livestock:					
U.S. farm supply[4]	$\Pi = \Sigma_i^n \theta_i L_i + \lambda[L_T - \Sigma_i^n L_i]$	$L_i^* (\theta_1, \ldots, \theta_n, L_T)$	GL and LOG	$\partial L_i^*/\partial \theta_i \geqslant 0$	$\partial L_i^*/\partial \theta_j = \partial L_j^*/\partial \theta_i$
U.S. processors' supply and demand[5]	$\Pi = \Sigma_i^n w_i Z_i + \lambda F(Z)$	$Z_i^* (w_1, \ldots, w_n)$	LOG	$\partial Z_i^*/\partial w_i \geqslant 0$	$\partial Z_i^*/\partial w_j = \partial Z_j^*/\partial w_i$
U.S. final demand[6]	$V = U(X) + \lambda[I - \Sigma_i^n P_i X_i]$	$X_i^*(P_1, \ldots, P_n, I)$	LOG	$(\partial X_i^*/\partial P_i)\vert_{\overline{U}} \leqslant 0$	$\partial X_i^*/\partial P_j + X_j^* \partial X_i^*/\partial I = \partial X_j^*/\partial P_i + X_i^* \partial X_j^*/\partial I$

[1]The generalized Leontief (GL) is a flexible functional form and provides a local second-order approximation to any arbitrary functional form (*4*). L and LOG denote a linear and log function, respectively.

[2]Π is regional field crop producers' profit; A_i is acreage planted; $\pi_i = r_i Y_i - VPCC_i$ is regional profit per acre where r_i is field crop output price; Y_i is field crop yield per planted acre; $VPCC_i$ is variable field crop production cost; and A_T is total crop land available for planting.

[3]Π is U.S. field crop processors' profit; r is a vector of output prices and input (field crop output) prices; and Q is a vector of outputs $Q_i \geqslant 0$ and inputs (production of field crops $Q_i = A_i Y_i$) $Q_i \leqslant 0$.

[4]Π is U.S. livestock producers' profit; L_i is livestock slaughter (liveweight) supply; $\theta_i = w_i ASW_i - VPCL_i$ is profit per animal where w_i is livestock output price, ASW_i is average liveweight at slaughter, and $VPCL_i$ is variable livestock production costs; and L_T is the total number of available animals which can be allocated between livestock enterprises.

[5]Π is U.S. livestock processors' profit; w is a vector of output prices and input (livestock producers' output) prices; and Z is a vector of livestock carcass outputs $Z_i \geqslant 0$ and livestock inputs $Z_i \leqslant 0$.

[6]U(X) is utility of final consumers; I is consumer income; and X_i is livestock final consumer demands.

$$\text{Own effect} \quad \partial A_i^* / \partial \pi_i \geqslant 0 \quad \text{for all i}$$

$$\text{Symmetry} \quad \partial A_i^* / \partial \pi_j = \partial A_j^* / \partial \pi_i \quad \text{for all } i \neq j \tag{4}$$

These restrictions were imposed as *a priori* information for each regional acreage equation. They imply that planted acreage for each crop increases with respect to its own per-acre net returns (own effect) and that the change in acreage of crop i with respect to net returns of crop j equals the change in acreage of crop j with respect to net returns of crop i.

As shown in table 3, we estimated most of the production equations in the model using a generalized Leontief functional form (*4*). This form is one of the so-called flexible functional forms because it provides a local second-order approximation to any arbitrary functional form. For the acreage equations in (2) it implies:[6]

$$A_i^* (\pi_1, \ldots, \pi_n) = \Sigma_j^n \gamma_{ij} (\pi_j/\pi_i)^{1/2} + \omega_i A_T$$

where γ_{ij} are estimated parameters. We estimated these equations with the restrictions in equations (4) for each region using restricted generalized least squares. The restrictions for regional acreage equations imply that:

$$\text{Own effect} \quad \partial A_i^* / \partial \pi_i = \Sigma_j^n - \gamma_{ij}/2\pi_j^{1/2} \pi^{-3/2} \geqslant 0$$

$$\text{Symmetry} \quad \partial A_i^* / \partial \pi_j = \partial A_j^* / \partial \pi_i = \gamma_{ij} = \gamma_{ji}$$

Using the same methodology, we specified and estimated equations to represent the other sectors according to the structure in table 3. The model in its presented version contains over 170 equations and was estimated with data for the 1961-77 period.

Estimated Regional Acreage Equations

We estimated the regional acreage and yield equations in 13 separate blocks using restricted generalized least squares (*10*). This estimation technique allows for correlation between error terms in a set of estimated equations and for the introduction of *a priori* information. Error terms for acreage within a region are likely to be correlated because of a fixed land base, whereas deviations of yields are likely to be correlated as a result of weather. Furthermore, yield and acreage are likely related because of the heterogeneous quality of land in a region.

The generalized Leontief form was used to estimate acreage response functions for each region. Initially, we obtained preliminary estimates for each region by imposing all *a priori* restrictions depicted in table 3 and by using the previous year's lagged crop acreage as a proxy for quasi-fixed production factors. However, the final choice of the estimated structure was based upon statistical properties and expected theoretical signs.[7] Table 4 illustrates the estimated acreage equations comprising the field crop production sector.

Each acreage equation has the expected economic sign with respect to own and cross net returns. Most of these signs are statistically significant at the 5-percent level. Only three equations were found that did not compete with other field crops. Hence, these equations were estimated as a function solely of their own net return. These equations are for corn in the TX and DS regions and for grain sorghum in the CB region.

Estimated Field Crop Demands

The estimated field crop demands are illustrated in tables 5, 6, and 7. Each table describes a set of equations that was estimated by separate blocks. The first block in table 5 represents the demand for seed use for each field crop. All the equations in this block have expected signs; only corn acreage was insignificant at the 5-percent level.

The food demand equations were estimated as per capita demands. All the expected signs for these equations are negative. However, only the own-price effects for grain sorghum and small grains were significant at the 10-percent level. Expenditure signs on all nonfood items were negative and were signif-

[6]The generalized Leontief form for the indirect profit function can be written as:

$$\Pi^* (\pi_1, \ldots, \pi_n, A_T) = \Sigma_i^n \Sigma_j^n \gamma_{ij} \pi_i^{1/2} \pi_j^{1/2} + \Sigma_i^n \omega_i \pi_i A_T$$

and one can obtain by use of the envelope theorem the following behavioral choice equation:

$$\partial \Pi^* / \partial \pi_i = A_i^* = \Sigma_j^n \gamma_{ij} (\pi_j/\pi_i)^{1/2} + \omega_i A_T$$

[7]Some inconsistencies between theory and results were expected. Hence, lagged acreages were omitted and time was included in some of the regions.

Table 4—Regional acreage equations

Region	Variable	Equation[1]
NW	AC	31.811 − 14.991 B12 + 0.634 AC(−1) (−1.39) (4.78)
	AG	1893.723 − 14.991 B21 + 0.606 AG(−1) (−1.39)
		Weighted R-square of system = 0.84
CA	AC	181.189 − 33.319 B14 + 0.521 AC(−1) (−6.28) (6.67)
	AG	1678.061 − 65.533 B23 + 0.304 AG(−1) (−3.04) (2.60)
	AGS	162.907 − 65.533 B32 + 0.115 AGS(−1) (−3.04) (5.68)
	ACT	118.717 − 33.319 B41 + 0.916 ACT(−1) (−6.28) (4.97)
		Weighted R-square for system = 0.93
MS	AC	938.176 − 666.184 B12 − 40.263 B13 (−4.68) (−0.92)
	AG	13832.550 − 666.184 B21 − 22.935 B23 (−4.68) (−0.34)
	AGS	365.935 − 40.263 B31 − 22.935 B32 (−0.92) (−0.34)
		Weighted R-square for system = 0.82
SW	AC	218.919 − 135.389 B13 (−6.54)
	AG	837.466 − 294.394 B24 + 0.497 AG(−1) (−7.27) (5.33)
	AGS	323.636 − 135.389 B31 + 0.492 AGS(−1) (−6.54) (2.97)
	ACT	491.599 − 294.394 B42 + 0.350 ACT(−1) (−7.27) (2.57)
		Weighted R-square for system = 0.67
CP	AC	1118.161 − 100.407 B14 + 0.844 AC(−1) (−2.00) (13.29)
	AG	3470.443 − 168.793 B23 − 520.051 B25 + 0.890 AG(−1) (−0.32) (−1.68) (11.09)
	AGS	8647.031 − 168.793 B32 − 2165.250 B52 (−0.33) (−4.47)
	ACT	437.985 − 100.407 B41 + 0.365 ACT(−1) (−2.00) (2.21)
	AS	3142.660 − 520.051 B52 − 2165.250 B53 + 0.589 AS(−1) (−1.68) (−4.29) (5.51)
		Weighted R-square for system = 0.94
NP	AC	2458.633 − 164.855 B13 + 0.142 AC(−1) (−3.38) (0.643)
	AG	2247.571 − 172.139 B25 + 0.899 AG(−1) (−1.40) (5.51)
	AGS	302.357 − 164.855 B31 + 0.354 AGS(−1) (−3.38) (2.03)
	AS	324.679 − 172.139 B52 + 0.639 AS(−1) (−1.40) (4.67)
		Weighted R-square for system = 0.56
TX	AC	−84.062 + 2.912 NRC(−1) + 0.959 AC(−1) (5.86) (14.87)
	AG	778.287 − 289.193 B25 + 0.969 AG(−1) (−3.81) (5.55)
	AGS	7594.079 − 897.729 B34 − 7.414 T (−1.78) (−0.22)
	ACT	3468.213 − 897.729 B43 − 0.478 ACT(−1) (−1.78) (3.34)

—Continued

Table 4—Regional acreage equations (Continued)

Region	Variable	Equation[1]
	AS	−618.208 − 289.193 B52 + 0.586 AS(−1) + 13.311 T (−3.66) (4.20) (1.84)
		Weighted R-square for system = 0.96
LS	AC	3825.292 − 1235.66 B12 − 1344.27 B15 + 0.839 AC(−1) (−1.74) (−1.85) (5.68)
	AG	10704.510 − 1235.66 B21 − 1456.42 B25 + 0.167 AG(−1) (−1.74) (−2.39) (0.90)
	AS	3200.874 − 1344.27 B51 − 1456.42 B52 + 0.861 AS(−1) (−1.85) (−2.39) (6.61)
		Weighted R-square for system = 0.60
CB	AC	25590.870 − 1087.35 B12 − 14669.80 B15 + 0.688 AC(−1) (−1.78) (−5.43) (6.07)
	AG	12460.780 − 1087.35 B21 − 3517.97 B25 + 0.457 AG(−1) (−1.78) (−6.08) (9.77)
	AGS	−39.831 + 5.759 NRGS(−1) + 0.605 AGS(−1) (1.95) (3.67)
	AS	18105.870 − 14669.80 B51 − 3517.97 B52 + 0.997 AS(−1) (−5.43) (−6.08) (11.90)
		Weighted R-square for system = 0.91
DS	log AC	0.193 + 0.064 log NRC(−1) + 0.938 log AC(−1) (1.37) (21.03)
	AG	987.851 − 262.371 B23 + 0.303 AG(−1) (−2.87) (2.10)
	AGS	369.159 − 262.371 B32 + 0.600 AGS(−1) (−2.87) (4.20)
	ACT	3624.093 − 1131.01 B54 + 0.129 ACT(−1) (−3.59) (1.14)
	AS	3465.740 − 1131.01 B54 + 0.834 AS(−1) (−3.59) (16.35)
		Weighted R-square for system = 0.93
SE	AC	3526.471 − 184.825 B15 (−4.05)
	AG	464.003 + 9.846 NRG(−1) + 0.359 AG(−1) (−1.50) (2.38)
	AGS	49.511 − 10.481 B34 + 0.418 AGS(−1) (−4.26) (8.11)
	ACT	370.777 − 10.481 B43 + 0.660 ACT(−1) (−4.26) (4.55)
	AS	486.319 − 184.825 B51 + 0.967 AS(−1) (−3.82) (12.39)
		Weighted R-square for system = 0.87
MA	AC	1728.898 − 80.570 B13 − 417.708 B15 + 0.702 AC(−1) (−1.84) (−1.76) (6.13)
	AG	200.835 − 129.432 B24 + 0.092 AG(−1) (−4.30) (0.66)
	AGS	280.877 − 80.570 B31 − 150.814 B35 + 0.711 AGS(−1) (−1.84) (−3.11) (5.06)
	ACT	271.224 − 129.432 B42 + 0.660 ACT(−1) (−4.30) (5.34)
	AS	−5706.940 − 417.708 B51 − 150.814 B53 + 0.565 AS(−1) + 113.899 T (−1.68) (−2.96) (3.45) (3.22)
		Weighted R-square for system = 0.92
NE	AC	923.411 − 344.238 B12 + 0.677 AC(−1) (−4.55) (3.29)
	AG	1139.900 − 344.238 B21 + 0.694 AG(−1) (−4.55) (7.93)
	AS	−22.238 + 2.042 + 0.867 AS(−1) (4.35) (9.48)
		Weighted R-square for system = 0.84

[1]Values in parentheses are t-values, and $B_{ij} = (NR_j/NR_i)^{1/2}$ where NR is lagged 1 year and i,j = 1 (corn), 2 (small grains), 3 (grain sorghum), 4 (cotton), and 5 (soybeans).

Table 5—Field crop demand equations

Block	Variable	Equation[1]
Seed	CSD	−68993.500 + 4.038 AC + 35.338 T (1.12) (7.36)
	GSD	−98821.800 + 60.990 AG + 50.823 T (4.72) (2.20)
	GSSD	−826.804 + 2.566 AGS + 0.460 T (2.60) (1.35)
	CTSSD	3838.336 + 14.523 ACT − 1.758 T (2.46) (−0.56)
	SBSD	13.911 + 0.825 AS (7.57)
		Weighted R-square for system = 0.85
Food	CFDD	−8240.090 − 3.113 PC − 0.219 EXP + 4.289 T (−1.35) (−6.25) (10.66)
	GFDD	−1246.210 − 2.927 PG − 0.098 EXP + 0.755 T (−3.28) (−3.92) (2.94)
	GSFDD	224.870 − 0.734 PGS − 0.006 EXP − 0.110 T (−1.88) (−1.50) (−1.83)
	CTSOFDD	20.017 − 0.084 PCTSO − 0.031 EXP (−0.76) (−4.28)
	SBOFDD	−1822.450 − 0.042 PSBO + 0.026 EXP + 0.934 T (−0.41) (1.63) (4.92)
		Weighted R-square for system = 0.93
Export	CED	−578684.000 − 18689.100 PC + 54797.350 D1 + 329.766 T (−3.09) (7.54) (0.45)
	GED	26588.800 − 1095.320 PG + 39565.980 D1 (−0.45) (11.59)
	GSED	−92888.800 + 11960.020 PC − 14669.800 PGS + 4333.833 D1 (2.21) (−2.26) (1.45)
Stock	CPSD	512270.300 − 21101.700 PC − 216.227 T (−5.69) (−0.61)
	GPSD	−3064436.00 − 15616.100 PG + 1597.586 T (−5.02) (3.26)
	GSPSD	−93163.90 − 3028.210 PGS + 52.424 T (−2.09) (0.44)
		Weighted R-square for system = 0.81
Cotton	CTLMD	10.450 − 0.300 PCTL + 0.021 EXP + 0.127 POLY (−2.40) (0.58) (2.70)
	CTLED	168455.600 − 71.947 PCTL + 148.116 PFCT − 34.803 WCTS − 85.400 T (−1.65) (1.97) (−0.50) (−0.95)
	CTLPSD	49617.700 − 48.208 PCTL + 185.543 WCTS + 219.888 CTLR − 255.650 T (−0.41) (0.94) (1.52) (−1.46)
		Weighted R-square for system = 0.69

[1]Values in parentheses are t-values and food demands are per capita.

Table 6—Soybean and cottonseed: Respective meal and oil supply identities and demand equations

Block	Variable	Equation[1]
Soybean	SBMP	SBCD * SBMYC
	SBOP	SBCD * SBOYC
	SBCD	−3809087.0 − 6345.890 PSB + 959.881 PSBM + 923.867 PSBO + 1962.221 T (−10.40) (4.80) (5.81) (18.34)
	SBPSD	−1154555.0 − 689.595 PSB − 0.124 SBGS + 0.184 SBPSD(−1) + 590.254 T (−0.76) (−1.15) (0.92) (2.45)
	SBED	−3456061.0 − 1534.45 PSB + 27.276 PFM + 1767.681 T (−2.54) (4.42) (11.47)
	SBMED	−1001169.0 − 318.354 PSBM + 12.848 PFM + 511.646 T (−0.57) (1.10) (8.11)
	SBOPSD	−73858.2 − 45.709 PSBO + 38.116 T (−3.04) (2.65)
	SBOED	−38850.0 − 2.640 PSBO − 0.124 SBOPL + 20.417 T (−0.15) (−1.28) (1.16)
		Weighted R-square for system = 0.97
Cottonseed	CTSMP	CTSCD * CTSMYC
	CTSOP	CTSCD * CTSOYC
	CTSCD	157266.5 − 245.177 PCTS + 98.759 PCTSO + 0.875 CTSP − 79.904 T (−1.71) (3.26) (36.46) (−5.64)
	CTSPSD	−134558.0 + 0.114 CTSP + 68.041 T (3.93) (4.86)
	CTSED	−9021.92 − 1.195 PCTS + 0.051 PFM + 4.606 T (−0.11) (0.36) (2.09)
	CTSMPSD	448.388 − 47.78 PCTSM (−1.49)
	CTSMED	−3892.89 − 57.807 PCTSM + 0.916 PFM + 2.044 T (−1.13) (1.55) (0.34)
	CTSOPSD	53321.89 − 7.749 PCTSO + 14.086 PSBO − 26.981 T (−3.43) (2.29) (3.84)
	CTSOED	−81185.4 − 45.299 PCTSO + 53.019 PSBO + 2.143 CTSOPL + 41.384 T (−3.32) (4.65) (8.93) (7.01)
		Weighted R-square for system = 0.98

[1]Values in parentheses are t-values.

Table 7—Feed-grain and feed meal demand equations

Block	Variable	Equation[1]
Grains	CFD	−5805774.0 + 20046.4 B12 + 74962.29 B13 + 12389.45 B14 (1.23) (4.34) (1.93) +3764.42 B15 + 17314.25 B16 + 2963.23 T (0.46) (0.96) (3.28)
	GFD	1216868.0 + 20046.4 B21 − 3162.01 B23 + 7762.688 B24 − 7235.78 B25 (1.23) (0.41) (2.94) (−2.01) + 9068.263 B26 − 618.38 T
	GSFD	(1.68) (−2.40)
	GSFD	−124649.0 + 74962.29 B31 − 3162.01 B32 − 18870.1 B34 (4.34) (0.41) (−2.81) + 4907.73 B35 + 17407.81 B36 + 590.35 T (1.08) (3.83) (2.47)
Meals	CTSMFD	−9401.66 + 12389.48 B41 + 7762.69 B42 − 18870.1 B43 (2.04) (3.10) (−2.96) + 9517.17 B45 + 380.62 B46 (3.08) (0.35)
	SBMFD	−1399818.0 + 3764.42 B51 − 7235.78 B52 + 4907.73 B53 (0.46) (−2.01) (1.08) + 9517.17 B54 + 2427.71 B56 + 715.51 T (2.92) (0.79) (6.71) Weighted R-square for system = 0.84

[1]Values in parentheses are t-values, and $B_{ij} = (P_j/P_i)^{1/2}$ for i=1 (corn), 2 (small grains), 3 (grain sorghum), 4 (cottonseed meal), and 6 (weighted price of livestock, WPL).

icant at the 5-percent level, except those for soybean oil.

Export and stock demands were grouped, and their estimated parameters are shown in the succeeding block. All own-price effects have the expected economic sign and are significant, except the small grains export demand equation. Dummy variables accounting for export shifts were significant for corn and small grains.

The final set of estimated equations in table 5 represents the residual cotton lint demands. Each own-price coefficient in these three equations is negative. The price of polyester for cotton lint fiber demand was positive and significant, implying that increases (decreases) in polyester prices decrease (increase) the mill demand of cotton lint. The last two equations, cotton lint export and stock demands, reflect the general statistical problems for stock and export equations. Even though we included many explanatory variables to describe behavior, insignificant coefficients were obtained.

Table 6 presents the estimated demands for soybean and cottonseed meal and oil equations. The first two equations in each block are supply identities for soybean and cottonseed meal and oil production. The yield coefficients are exogenous, as they changed little during the estimation period.

The first equation, soybean crushing demand, depicts significant coefficients for each explanatory variable. Prices of soybean meal and oil (the outputs of soybeans after crushing) have positive signs. Several difficulties were encountered with the equation for soybean private stocks. A different assortment of explanatory variables was initially included in this equation. However, except for the illustrated specified form, they each gave a positive own-price effect. All coefficients for the soybean export equation were significant. The price of foreign fish meal had a significant and positive sign, indicating substitute products. The last four equations in this block represent the export and stock demands for soybean meal and oil. All own-prices have the expected signs.

The cottonseed block depicts demands for cottonseed, cottonseed oil, and cottonseed meal. The first equation in the block CTSCD gave poor statistical results except when cottonseed production was included. We estimated cottonseed private stocks using cottonseed production and time as the only variables. Although the price of cottonseed was initially specified in the equation, its estimated coefficient was positive and insignificant. We also encountered incorrect signs and insignificant coefficients in the cottonseed export demand equation. However, the illustrated specified form gave expected signs even though some coefficients were insignificant. The remaining equations show the estimated coefficients for cottonseed meal and oil stock and export demands. The own-price effects have the expected sign and are significant for the last two equations.

We estimated the feed demand equations (table 7) with symmetry imposed on feed prices. All the own-price effects are negative and significant, indicating downward-sloping functions. Examining cross signs reveals that corn is a substitute for all feeds. Other substitutes are soybean meal and grain sorghum, small grains, and cottonseed meal and soybean meal.

Livestock Supply Equations

Table 8 shows the livestock supply equations. In the beef block, the number of cattle placed on feed (CPOF) or not placed on feed (RCI) is determined by expected net returns for each alternative. After determining placements, we explained fed beef production (FBPP) by lagged cattle placed on feed and by the relative prices of farm fed beef and the weighted feed-grain price index. A similar result is used to explain nonfed beef production (NFBPP). An interesting result of the shortrun production response is that fed beef production shows a positive response to its own price and a negative response to a weighted feed grain price, whereas nonfed beef production shows the converse. Hence, a rise in feed-grain prices decreases fed beef production and an increases nonfed beef production.[8]

The next block explains pork supplies. The number of sows farrowing is explained by net returns of barrows and gilts, the number of pigs per litter, and the previous year's sow farrowings. The number of pigs on feed is then explained by sow farrowings and the previous year's pigs on feed. The shortrun

[8]These results are similar to those of Jarvis (*6*)

Table 8—Livestock supply equations

Block	Variable	Equation[1]
Beef	FBPP[2]	6024.356 − 13997.40 COFB + 1025.044 CPOF(−1) (2.40) (28.34)
	FBP	0.5858 FBPP (28.34)
	PFFB	0.3004 PRFB (96.82)
	NFBPP[2]	10108.640 CONFB + 683.459 RCI(−1) (5.20) (11.19)
	NFBP	0.5834 NFBPP (450.07)
	PFNFB	0.3073 PRNFB (42.43)
	CPOF[3]	38.986 − 37.408 R12 + 0.878 CPOF(−1) (−4.74) (20.58)
	RCI[3]	42.023 − 37.408 R21 + 0.754 RCI(−1) (−4.74) (14.05)
		Weighted R-square for system = 0.99
Pork	PPP[2]	−11209.5 COP + 311.803 POF(−1) + 4.217 T (9.57) (4.50)
	PP	0.638 PPP (74.81)
	POF	3.799 SFAR + 0.051 POF(−1) (15.65) (0.84)
	SFAR	0.022 NRBG(−1) + 0.466 SFAR(−1) + 0.591 PPLIT (1.82) (2.71) (1.31)
	PFP	0.314 PRP (38.36)
		Weighted R-square for system = 0.99
Sheep	SPP[2]	96.625 − 1018.62 COS + 437.79 SPOF(−1) (−2.23) (19.21)
	SP	0.488 SPP (742.83)
	SPOF	0.153 SBHI(−1) (64.11)
	PLF	0.256 PRL (72.69)
	log SBHI	891.856 + 0.922 log NRL(−1) − 117.76 T (2.82) (43.55)
		Weighted R-square for system = 0.99
Imports	log NFBI	0.201 log PRNFB(−1) + 0.895 log NFBI(−1) (1.10) (8.86)
	log PI	0.155 log PRP(−1) + 0.897 log PI(−1) (1.93) (15.56)
	log NSI	0.058 log PRL(−1) + 0.916 log NSI(−1) (0.43) (6.65)
		Weighted R-square for system = 0.99

[1]Values in parenthese are t-values.
[2]$CO_i = (WPF/PF_i)^{1/2}$ where i = FB (fed beef), NFB (nonfed beef), P (pork), and L (lamb).
[3]$R_{ij}{}^{1} = (NR_i/NR_j)^{1/2}$ where NR is lagged 1 year, and i,j = 1 (fed beef), and 2 (nonfed beef).

pork production equation is positively sloped with respect to the farm price of barrows and gilts.

The sheep and lamb production block is structurally similar to the other livestock production blocks. The net returns for lambs positively influences the sheep breeding-herd inventory, and the number of sheep placed on feed is explained by lagged breeding-herd inventories. Sheep production is positively sloped with respect to the farm price of lambs and negatively related to weighted feed-grain price. The last three equations explain livestock imports of each livestock group.

Livestock Demand Equations

Table 9 shows the livestock demands. For domestic retail demands, we imposed the theoretical restrictions for final consumer demands. Although each own price is highly significant, only pork demand is inelastic. The estimated income elasticities (2.07, -0.64, 0.37, 0.95) indicate that fed beef is a superior good whereas nonfed beef is an inferior good. Arzac and Wilkinson (*2*) obtained similar results. The last set of equations explains stock and export demands for the livestock sector of the model. Each equation gives expected negative own-price effects.

Total Welfare Estimation by TECHSIM

Welfare measures in competitive markets have received considerable attention in recent years. Mishan (*8*) demonstrated that in a partial equilibrium setting, producer surplus is a measure of industry quasi-rents (shortrun net returns) to fixed production factors of the industry. In contrast to this partial equilibrium approach, Anderson (*1*) and, more recently, Just and Hueth derived welfare measures from both partial and general equilibrium (that is, all prices and quantities in the economy are allowed to vary). These studies considered only the case where the distortion results from direct

Weighted R-square for system = 0.99

Table 9—Livestock demand equations

Block	Variable	Equation[1]
Domestic	log FBDD	−6.98 − 1.980 log PRFB + 0.501 log PRNFB − 0.381 log PRP (−15.39) (4.57) (5.89) + 0.009 log PRL + 2.076 log I (0.32) (26.53)
	log NFBDD	9.412 + 2.105 log PRFB − 2.806 log PRNFB + 0.463 log PRP (9.15) (−9.79) (3.64) + 0.048 log PRL − 0.644 log I (1.13) (−2.47)
	log PDD	1.731 + 0.241 log PRFB + 0.115 log PRNFB − 0.670 log PRP (2.67) (1.46) (−10.23) + 0.038 log PRL + 0.371 log I (1.82) (6.16)
	log SDD	0.634 + 0.826 log PRFB + 0.513 log PRNFB + 0.700 log PRP (1.00) (0.55) (1.50) −3.829 log PRL + 0.952 log I (−4.07) (0.99)
Stocks	log NFBSD	−0.829 log PRNFB + 1.198 log T (−1.22) (3.31)
	log PSD	−178.72 − 0.457 log PRP + 0.635 log PRP(−1) + 24.1924 log T (−0.60) (0.94) (1.25)
	log SSD	−1.263 log PRL + 1.877 log PRL(−1) (−1.46) (2.16)
Exports	log NFBED	4878.3 − 3.085 log PRNFB + 8.627 log FLPI − 641.189 log T (−1.98) (3.25) (8.23)
	log PED	−683.95 − 1.766 log PRP + 91.842 T (−1.74) (3.68)

[1]Values in parentheses are t-values.

price alterations. However, a number of policy questions do not pertain to direct price distortions, but rather to nonprice or technological changes that may result from changes in technology or Government regulations.[9] Thus, Chavas and Collins derived welfare measures of a technological change in general equilibrium for related multiproduct and multifactor industries. They found that an exact change in total welfare from a technological change in a general equilibrium framework for a multi-industry economy is given by:

$$\Delta W = \Sigma_i^m \Delta T_{1i}^+ - \Sigma_i^n \Delta T_{1i}^- + \Delta I \tag{5}$$

where ΔW is the exact change in total welfare, ΔT_{1i}^+ is the change in technical rents of m outputs of industry 1, ΔT_{1i}^- is the change in technical rents of n inputs of industry 1, and ΔI is the change in consumer income.

The results in equation (5) show that changes in total welfare can be derived from changes in consumer income and technical rents (defined as the area under the supply or demand curves) in the industry distorted, where all measurements are made in a general equilibrium setting. For an econometric simulation model, equation (5) implies that if the general equilibrium equations are linear, then the technical rents measuring the change in total welfare are provided by:[10]

$$\begin{aligned}\Delta W = {} & \Sigma_i^m .5[y_{1i}(a_1) - y_{1i}(a_0)]\ [P_{1i}(a_1) \\ & + P_{1i}(a_0)] - \Sigma_i^n .5[x_{1i}(a_0)]\ [r_{1i}(a_1) \\ & + r_{1i}(a_0)] + I(a_1) - I(a_0)\end{aligned} \tag{6}$$

where y_{1i}, x_{1i}, P_{1i}, r_{1i}, and I are the respective output supply (m outputs), input demand (n inputs), output prices, input prices, and consumer income before and after the technical change in the parameter a.

Thus, to evaluate the change in total welfare in the economy, we need information only on the general equilibrium prices and quantities in the distorted industry before and after the technological change and the change in consumer income. If the consumer income effect is small or if it is neglected, then equation (6) is similar to the previous results of Harberger (5).

In the case of TECHSIM, technological changes within the firm can be reflected by changes in either yields or variable production costs of both field crop and livestock sectors.[11] For TECHSIM, equation (5) implies that one can show the change in total welfare when the field crop sector is distorted in the following manner:

$$\begin{aligned}\Delta W = {} & \Sigma_j^{13} \Sigma_i^6\ .5[Q_{ij}(a_1) - Q_{ij}(a_0)]\ [P_i(a_1) \\ & + P_1(a_0)] - [A_{ij}(a_1) - A_{ij}(a_0)] \\ & [C_{ij}(a_1) + C_{ij}(a_0)] + I(a_1) - I(a_0)\end{aligned} \tag{7}$$

where Q_{ij}, A_{ij}, C_{ij}, P_i, and I are production, acreage planted, variable production cost of the ith crop in the jth region, field crop output prices, and consumer income respectively.[12]

Distribution of Welfare

Although equation (7) shows the total welfare impact, the distribution of rents is also computed. For example, the change in crop rent by region is simply the difference in net returns before and after the technological change. We computed the change in industry rents for other agricultural sectors using the results of Just and Hueth for price distortions because prices will indirectly change following technological changes in the field crop sector.[13] This implies that one can obtain the change in industry rents for soybean meal and the oil industry by taking first differ-

[9] A nonprice, or technological, distortion implies that the source of the distortion is not an exogenous price alteration. In this context, all prices are assumed to be affected only indirectly, assuming profit maximization and perfect competition.

[10] If the general equilibrium functions are nonlinear, then equation (5) provides only an approximation.

[11] Note that the source of the change is directly attributed to nonprice distortions even though all prices will change indirectly.

[12] The six field crops are i = 1 (corn), i = 2 (small grains), i = 3 (grain sorghum), i = 4 (cotton), i = 5 (cottonseed), and i = 6 (soybeans), respectively. The 13 regions are depicted in the figure.

[13] Just and Hueth show that one can obtain the kth industry rent by taking the difference between the consumer surplus of the kth industry and the consumer surplus of the k-1 industry or:

$$\Delta\Pi_k = -\Delta CS_k + \Delta CS_{k-1}$$

where ΔCS is the change in consumer surplus for the respective markets.

ences between consumer surpluses of soybean meal and oil and soybean crushings. A similar procedure is used to compute cottonseed meal and oil industry rent. The remaining distribution of field crop sector rents is given by the change in consumer surpluses for field crops. We use these consumer surplus measures to calculate the sum of rents and final consumer surpluses beyond the farm gate for those industries using these crops as intermediate inputs and for those consumers ultimately consuming them.

The distribution of rents to the livestock sector is given by the rents to each livestock group (fed beef, nonfed beef, pork, and sheep). One determines livestock wholesale and retail producer rents by taking first differences between the appropriate consumer surpluses. The last welfare measure is the sum of final consumer surpluses for livestock consumers.

Summary

Unlike most econometric models, the welfare measures for TECHSIM reflect both distribution of rents throughout the agricultural sector and the total welfare impact. This model improves the basis for determining which group(s) within a sector gain(s) or lose(s) as a result of technological change. The model also makes practical use of theory by incorporating *a priori* information on the structure of the agricultural sectors modeled during estimation.[14] The next article applies the model to assess the welfare implications for boll weevil/cotton insect management.

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Appendix

Consider minimization of the following primal-dual problem:

$$L^* = \Pi^* - \Pi$$

where Π^* and Π are the respective indirect and direct profit functions. From Silberberg (*9*), L^* must

[14] The livestock sector has limited applications to policies affecting dairy and poultry because these sectors were not explicitly modeled.

be positive semidefinite. This implies that the following matrix must be semidefinite:

$$\partial^2 L^*/\partial\pi_i\partial\pi_j = \begin{bmatrix} \partial^2 L^*/\partial\pi_1\partial\pi_1 & \cdots & \partial^2 L^*/\partial\pi_1\partial\pi_n \\ \vdots & \ddots & \vdots \\ \partial^2 L^*/\partial\pi_n\partial\pi_1 & \cdots & \partial^2 L^*/\partial\pi_n\partial\pi_n \end{bmatrix} \quad \text{(A1)}$$

Hence, all principal minors of matrix (A1) must be nonnegative; these consist of the following typical elements:

$$\partial^2 L^*/\partial\pi_i\partial\pi_j = \partial^2 \Pi^*/\partial\pi_i\partial\pi_j - \partial^2 \Pi/\partial\pi_i\partial\pi_j \quad \text{(A2)}$$

Silberberg has shown that equation (A2) is equivalent to:

$$\partial^2 L^*/\partial\pi_i\partial\pi_j = \Sigma_k^n\, (\partial^2 \Pi/\partial\pi_i\partial A_k)\,(\partial A_k^*/\partial\pi_j) \quad \text{(A3)}$$

Equation (A3) involves the partial derivatives of the behavioral choice functions in equation (2). The conditions on the bordered Hessian determinants of the terms in (A1) place restrictions on the size and sign and also represent the known implications of the producer objective function in equation (1). Applying equation (A3), one obtains the following elements of matrix (A1):

$$\partial^2 L^*/\partial\pi_i\partial\pi_j = \begin{bmatrix} \partial A_1^*/\partial\pi_1 & \cdots & \partial A_1^*/\partial\pi_n \\ \vdots & \ddots & \vdots \\ \partial A_n^*/\partial\pi_1 & \cdots & \partial A_n^*/\partial\pi_n \end{bmatrix} \quad \text{(A4)}$$

Positive semidefiniteness of matrix (A4) implies that the diagonal elements are nonnegative:

$$\text{Own effect} \qquad \partial A_i^*/\partial\pi_i \geqslant 0 \ \text{ for all i} \qquad \text{(A5)}$$

Furthermore, because matrix (A4) is symmetric, one can add the following additional restrictions:

$$\text{Symmetry} \quad \partial A_i^*/\partial\pi_j = \partial A_j^*/\partial\pi_i \quad \text{for all } i \neq j \quad \text{(A6)}$$

Aggregate Economic Effects of Alternative Boll Weevil Management Strategies

By C. Robert Taylor, Gerald A. Carlson, Fred T. Cooke, Jr., Katherine H. Reichelderfer, and Irving R. Starbird*

Abstract

This article presents an aggregate benefit-cost analysis of alternative areawide boll weevil eradication and management strategies. Economic efficiency effects of the programs were measured in terms of consumer benefits, farm income, and public program costs; TECHSIM—an econometric simulation model of production and consumption of major U.S. agricultural crops—was used to estimate market impacts of the programs. Boll weevil eradication, combined with pest management, was found to have the highest net social benefits. However, this program also had the highest public (taxpayer) costs. An optimum pest management alternative without eradication had the highest benefit-cost ratio, but had next to lowest net social benefits. Choice of the best boll weevil program depends on budget priorities and the target group for program implementation.

Keywords

Benefit-cost evaluation, pest management, pest eradication

Boll weevils infest about 7 million acres of cotton in areas extending from Virginia to central Texas. Since shortly after the boll weevil first infested U.S. cotton in the late 1890's, the insect has ranked high, if not the highest, among insects causing economic damage to U.S. crops. In addition to direct economic damage caused by the pest, the substantial amounts of insecticides used to control boll weevils have apparently resulted in serious environmental problems.

In view of the economic and environmental problems posed by the boll weevil and in recognition of the technical and operational advances in its control, the U.S. Department of Agriculture (USDA) initiated comprehensive biological, environmental, and economic evaluations to assess the potential of alternative areawide boll weevil eradication[1] and management strategies. This article presents results of the national economic evaluation.

The economic evaluation emphasized the aggregate economic efficiency and distributional impacts of alternative areawide strategies for boll weevil control. Net economic efficiency was defined in terms of consumer benefits (consumer surplus), farm income and public program costs. Distributional impacts were measured in terms of consumer benefits, regional farm income, and taxpayer costs.

Because any large-scale pest control program affects not only the market for the target crop but also related markets, aggregate economic evaluations of such programs are improved if they are conducted in a general equilibrium framework; otherwise, price, quantity, and surplus estimates would be biased. In light of this situation, TECHSIM, a regionalized econometric simulation model for the production and consumption of major U.S. field crops, was used to estimate market impacts of alternative boll weevil control programs as reflected in regional per-acre yields and production costs. The version of TECHSIM utilized for this analysis did not include an explicit livestock sector, but it is otherwise essentially the same as the version reported in the first article in

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[1]Authorization for public-sponsored areawide boll weevil management programs is given to the Secretary of Agriculture in the 1973 Agricultural and Consumer Protection Act, P.L. 93-86 (*3*). Italicized numbers in parentheses refer to items in the References at the end of this article.

this issue. The version used for this analysis is reported in (*2*).

We define alternative programs considered in the evaluation in the next section. Then, we present regional insect control costs, yields, public program costs, and implementation data that are critical to an aggregate analysis. We discuss the benefit-cost framework, and we present national impacts of alternative programs, followed by estimates of distributional impacts. Finally, we discuss uncertainties and implications of the analysis. USDA reports (*4*, *5*, *6*, *7*) provide additional details on the economic evaluation and results.

Alternative Boll Weevil/Cotton Insect Management Programs

Six programs were chosen for evaluation:

1. Current insect control (CIC) assumes insect control as now practiced by cotton producers with a continuation of extension education and technical assistance at current funding levels.

2. Optimum pest management with continuing incentives for boll weevil management (OPM-I) uses relevant boll weevil/cotton insect management practices over all acreage where boll weevils are currently a pest problem. This acreage would receive areawide diapause and/or pinhead square treatments,[2] as needed, with full reimbursement to producers for treatment costs. All areas where the areawide diapause strategy could not be implemented or where it is not needed because of an absence of boll weevils would utilize, if applicable, all relevant practices except the organized areawide diapause treatment. Additional extension personnel and support would be provided in all areas of the 11 weevil-infested States.

3. Optimum pest management with phased incentives (OPM-PI) includes the same management practices and recommended technical components as OPM-I, except that incentive payments for diapause or pinhead square treatments decrease annually over a 4-year period from full reimbursement in the first year to no reimbursement in the fifth year.

4. Optimum pest management with no incentives (OPM-NI) includes the same management and technical components of the beltwide program specified for OPM-I, except that producers are not reimbursed for diapause or pinhead square treatments.

5. Optimum pest management with boll weevil eradication (OPM-NI-BWE) includes eradication of the boll weevil as a major component.[3] To achieve efficient implementation and to take advantage of the absence of the boll weevil, OPM-NI, including its additional extension inputs, would be in place before, during, and after eradication. Eradication would begin in the Southeast and proceed west through eight separate zones, followed by the maintenance of a buffer zone between the United States and Mexico to inhibit reinfestation.

6. Current insect control with boll weevil eradication (CIC-BWE) would be implemented with current levels of funding for extension education for cotton insect management before, during, and after eradication. The eradication component of this program would be the same as for OPM-NI-BWE.

Associated with each of the programs are unique sets of producer insect-control costs, cotton lint yields, and public program costs, all based on program components. Consequently, each was expected to have a different impact on the markets for cotton and other crops and on distributional and economic efficiency.

Regional Data

National economic evaluation of alternative boll weevil management options required us to estimate lint yield and per-acre insecticide use data, and to compare public expenditures for each option. Esti-

[2] Diapause control refers to late-season insecticide treatment, timed to affect reproductive adult weevils prior to their overwintering. The timing is such that few or no same-year yield benefits result. The treatment is aimed at reducing the level of next year's resident weevil population. Therefore, diapause treatment is often not conducted by producers whose decisions are based on shortrun, intraseasonal considerations. Pinhead square treatment is an early season control strategy which also occurs at a time that might not be chosen by a shortrun profit-maximizing producer. Both strategies are relatively ineffective if not practiced over a large area.

[3] One reason that boll weevil eradication has some chance of success is that the boll weevil can survive only on cotton and on a few wild host plants found exclusively in southern Texas.

mation of regional yield impacts was especially difficult as little empirical evidence was available on a regional or beltwide basis. Because experiments would be too costly and time consuming to provide the yield and cost data needed for each alternative insect management strategy, we investigated the possible contributions of the following three approaches to obtain the yield and cost impacts: (1) multiple regression, (2) simulation, and (3) Delphi. As regression and simulation data were not available for all cotton regions, we obtained yield and insecticide cost data using a structured Delphi process for the 32 weevil-infested regions shown in figure 1.

Delphi is a process by which a panel of experts is polled for information; each member of the panel is given feedback on the range and variation of initial response, and then members are polled again. Delphi insecticide use and yield estimates were developed by a broad group of individuals representing cotton research, Cooperative Extension Service (CES), production, management consulting, and the chemical industry. Delphi panelists were identified as experts by a representative of each respective group. Because consistent data on cotton insects and their control for all weevil-infested regions are lacking and because attempts to generate these data through various analytical techniques have been unsuccessful, the subjective judgments of the expert Delphi panelists represent the best available estimates of the average subregional farm-level impacts of a change in boll weevil/cotton insect management programs. In an evaluation of the Delphi results, we also found that the estimates generally fall within the range of available estimates from other partial sets of subjective or historical data (*5*).

Producers' Insect Control Costs

Strong linkages and interactions exist among boll weevil, bollworm (*Heliothis*), and other insect management practices. Some chemicals and many treatments are used to control more than one insect. Primary treatments against one pest often result in secondary effects on other insects. The program options including an OPM component recognize these interactions by addressing insect management in a holistic framework. Insecticide use and cost estimates were also collected and expressed in terms of the total insect complex and control scenario.

Figure 2 summarizes estimates of U.S. producer costs of insect control for alternative management programs. Costs of insecticide materials and their application costs are included. These estimates are based on Delphi results for longrun average levels of

Figure 1

Cotton Production Regions

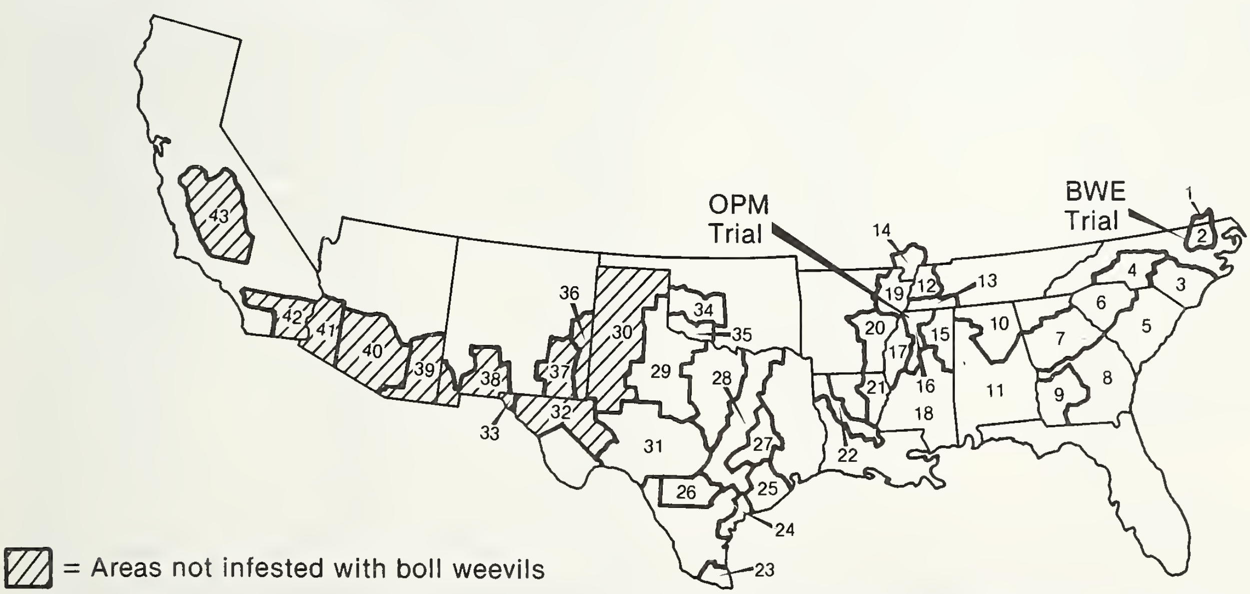
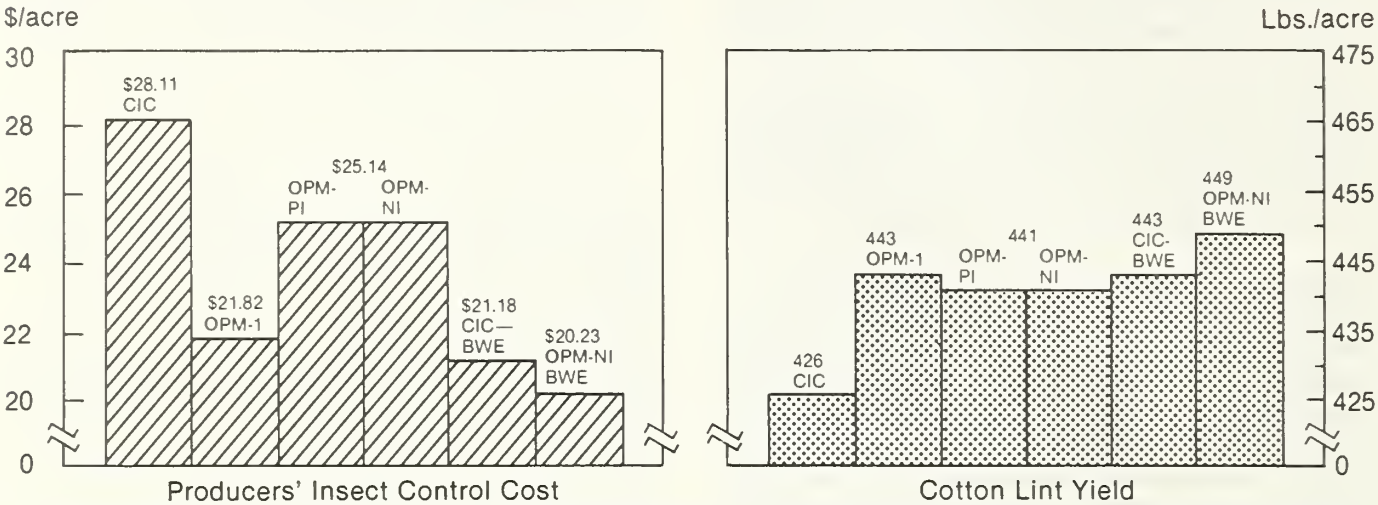


Figure 2

Average Producer Insect Control Costs and Lint Yields by Boll Weevil/Cotton Insect Management Program, Boll Weevil-Infested States (Exclusive of Texas Subregions 30, 32 and 33)



infestation. Cost levels associated with OPM and BWE programs represent full implementation of the respective programs and full adjustment by producers.

Insecticide use and costs vary widely across production regions. Although CIC costs are generally highest in the Southeast, costs are also high in some areas of Texas, notably the Central River Bottoms (region 27) and Winter Garden (region 26), and in Louisiana. Some areas, including Missouri, northeast Arkansas, and the Rolling Plains and Upper Concho regions of Texas, generally experience little insect pressure.

Insecticide applications and producer costs per acre following implementation were generally lowest for the two eradication programs. Costs for OPM-NI-BWE were higher than those for CIC in Missouri and northeast Arkansas, where Delphi panelists indicated that current control practices for insects other than boll weevils were inadequate and would likely be corrected with added extension education.

Cotton Lint Yields

Figure 2 summarizes Delphi estimates of lint yields for the six U.S. management programs. CIC yields correspond closely with average 1969-78 yields provided to Delphi panelists, with some modifications as estimated by panelists. Yields for other programs were estimated as changes from the CIC base.

All programs increase yields. Incremental yield increases are generally greater from CIC to OPM-NI than from OPM-NI to any other option. This finding reflects the panelists' belief that additional extension education and technical assistance would improve cotton insect management and boost yields. Yields for OPM-PI and OPM-I either equal or slightly exceed those for OPM-NI. Panelists believed that the addition of an areawide diapause program with incentives would not greatly increase yields above those associated with an increased extension education and information program. Yield increases for CIC-BWE are lower than those associated with the OPM programs in most regions in the Southeast and mid-South. The implication is that OPM programs would improve management of all cotton insects, whereas CIC-BWE impacts relate to eradication of the boll weevil only. However, in most regions of eastern Texas, yields are higher for CIC-BWE than for OPM programs. This may indicate that the boll weevil is more often the key pest in eastern Texas, whereas other key pests may predominate in the mid-South and Southeast.

In most regions, OPM-NI-BWE average yields are higher than those for other programs, except for some regions where yields equal OPM-I. The chief rationale for higher yields, as well as for lower producer costs, for the OPM-NI-BWE program is that it combines the advantages of increased extension input and boll weevil eradication.

Public Program Cost Data

Public cost is an important element in the economic evaluation of beltwide cotton insect management programs. A Program Definition and Cost Facilitator Group, comprised of members of public institutions that would implement the various programs, specified guidelines and coordinated the review of Animal and Plant Health Inspection Service (APHIS) and CES estimates of public costs for the six programs (7). Program costs for implementing beltwide programs were estimated for each of 32 cotton production regions in boll weevil-infested areas (fig. 1).

Public costs include all Federal and State costs associated with each of the boll weevil/cotton insect management programs, including incentive payments to producers where applicable. Incentive payments for diapause and pinhead square treatments under the OPM program were based on Delphi estimates of farmers' needs for such treatments (*5*). In this analysis, producers were assumed to pay 50 percent of eradication operational costs.[4] All research and development costs were excluded because past investments are not relevant to the choice among current alternatives. Regular county extension personnel were not included in these computations because their number is unlikely to vary by the choice of insect management program. However, county extension entomologists assigned specifically to cotton were included.

We forecast neither changes in input price levels during the implementation period nor changes in relative price levels of different inputs. We assumed technology was unchanged from existing on-the-shelf procedures during the evaluation period.

The pattern of estimated public costs for each of the beltwide programs varies considerably from initiation through full implementation (table 1). It would cost an estimated $460 million, including capital investments, during the 9 years to eradicate the boll weevil.

[4]Other cost-share arrangements (for example, Government provision of two-thirds of total cost) were evaluated with no change in program ranking. This occurred because cost-shares affected only producers' profit during the 2 years of eradication implementation.

Table 1—Annual public costs for beltwide boll weevil cotton insect management programs, years 1-15

Year	CIC	OPM-I	OPM-PI	OPM-NI	OPN-NI-BWE[1]	CIC-BWE[2]
	Million dollars					
1	2.5	5.6	5.5	4.7	6.2	2.5
2	2.5	35.8	35.6	6.9	19.1	12.1
3	2.5	35.8	28.9	6.9	46.2	39.2
4	2.5	35.8	22.1	6.9	79.5	72.5
5	2.5	35.8	6.9	6.9	94.3	87.3
6	2.5	35.8	6.9	6.9	74.0	67.1
7	2.5	35.8	6.9	6.9	51.0	44.1
8	2.5	35.8	6.9	6.9	74.1	67.2
9	2.5	35.8	6.9	6.9	65.4	59.3
10	2.5	35.8	6.9	6.9	21.1	16.0
11	2.5	35.8	6.9	6.9	7.7	3.3
12	2.5	35.8	6.9	6.9	7.5	3.1
13	2.5	35.8	6.9	6.9	7.5	3.1
14	2.5	35.8	6.9	6.9	7.5	3.1
15	2.5	35.8	6.9	6.9	7.5	3.1

[1]Includes all eradication program costs as well as related OPM-NI and followup monitoring costs. Public costs would be lower than these amounts if farmers share some of the eradication costs.
[2]Assumes constant 1979 dollars and constant 1974-78 average cotton acreage.

If farmers share part of the eradication costs, public expenditures under eradication programs would be reduced. CIC and the three incentive-related OPM programs would be funded through CES, whereas the two eradication programs, CIC-BWE and OPM-NI-BWE, would be jointly funded by CES and APHIS.

Schedules Assumed for Program Implementation

Recognizing that programs would probably not be fully implemented in the first year and that producer impacts and adjustments would not take place immediately, we made simplifying assumptions to reflect the dynamics of implementation.

To promote comparability of results, we assumed that all programs would be initiated in the same year. For the OPM programs (OPM-NI, OPM-PI, and OPM-I), we assumed that 50 percent of program personnel and related resources would be in place in year 1, and 100 percent in place in year 2. Incentive payments to producers for any diapause/pinhead square treatments would start in year 2 at the full funding level. For the OPM-NI-BWE program, an OPM-NI option would be implemented in all regions in year 1, the year immediately preceding initiation of eradication in southern North Carolina. In North Carolina and in South Carolina, we assumed that the OPM-NI option would be fully staffed in year 1, whereas staffing would take place over a 2-year period in the other States. Eradication would be phased across the Cotton Belt in eight zones, starting in year 2 in North Carolina and ending in year 10 in the lower Rio Grande Valley of Texas. Eradication activities are completed in 2 years within a given zone and are followed by continuous monitoring for incipient infestations.

Eradication activities in the CIC-BWE program take place in the same sequence as those for OPM-NI-BWE, except that no additional CES personnel are funded.

Estimates of changes in cost and yield obtained from the Delphi panels provided the primary basis for evaluating aggregate economic impacts of alternative management programs. However, Delphi estimates reflect the impacts of full implementation of the programs. Inasmuch as it is unrealistic to assume full implementation in the first year, we estimated annual responses of producers' costs and yields to the adoption of given programs (table 2). These estimates were made by the respective trial program operations in APHIS and CES. All changes were measured from the CIC base except for OPM-NI-BWE, which is based on OPM-NI. We report the sensitivity of other selected assumptions relating to implementation scheduling later in this article.

Additional critical assumptions relate to the effectiveness of programs and the rates of producer participation. The evaluation assumes that the technologies and practices specified for use in weevil-infested regions would successfully eradicate or suppress the boll weevil as indicated in each plan. We also assumed that producers would participate in the respective programs as estimated by the Delphi panels. Mandatory participation is specified for eradication. For OPM programs, the Biological Evaluation Team (BET) estimated the extent of farmer participation needed, by regions or by areas within regions. In heavily infested areas, the percentage of required acreage exceeded 90 percent. In some areas, much less acreage was required because of historically low weevil infestation. Delphi estimates of participation were matched against the BET estimates of required acreage. In some areas, expected participation was less than that required, in which case the program impacts on that acreage reflected a modified OPM option (extension information and technical assistance) without organized

Table 2—Time-phasing of changes in lint yields and costs during implementation of alternative programs

Program	Percentage of difference from CIC		
	Year 1	Year 2	Year 3
	Percent		
OPM-NI	25	75	100
OPM-PI and OPM-I	50	100	100
CIC-BWE[1]	0	75	100
OPM-NI-BWE[1]	25	75	100

[1]Year 1 for both eradication options refers to first year of fall diapause applications in a given region. Prior to eradication in the OPM-NI-BWE program, which is phased across the Cotton Belt, an OPM-NI program will be in effect. During those early years, the OPM-NI percentages apply to Delphi estimates of change for that program. When BWE is initiated, the adjustment from OPM-NI to OPM-NI-BWE takes place according to the 25-75-100 scale.

diapause/pinhead square treatments or incentive payments. In most regions, the OPM-NI and OPM-PI programs were judged not to be effective in eliminating the need for midseason treatments for the boll weevil on at least 90 percent of the cotton acreage prior to *Heliothis* treatments. However, the OPM-I program was assumed to be fully effective where needed to fulfill the above performance requirements. Similarly, the eradication component of CIC-BWE and OPM-NI-BWE programs was assumed to be fully effective beltwide, and the followup monitoring program was assumed to detect and control incipient populations or reinfestations.

Benefit-Cost Evaluation Framework

In the absence of external impacts, the present value of changes in consumer surplus plus changes in producer surplus minus all public program costs can satisfactorily measure the national net market benefits of a program. Although objections have been raised against this approximation of social benefits, we believe there is no better empirically operational measure. It is not an all-inclusive measure of net social benefits, as it excludes environmental factors, human hazards, aesthetics, potential pesticide resistance, and other possible impacts that decisionmakers should consider. These added considerations, however, have not been quantified and thus could not be assessed in monetary terms.

Economic impacts of alternative management programs on producers of raw agricultural crops were measured as the change in net returns for each respective management program relative to CIC. For this study, we defined producer surplus as the difference between gross returns and variable production costs, a definition which is consistent with net return variables in TECHSIM supply equations. For producers' net returns to be a valid measure of producer surplus, real prices of production inputs must be constant over the relevant range of changes in input use that could be attributed to implementing any of the management programs. Constant input prices appear to be a realistic assumption.[5]

[5]We explicitly considered exceptions to this assumption in estimating specialized monitoring and manpower resource requirements for eradication and pest management programs.

In this article, the term "consumers" has a very broad meaning and includes all market participants beyond the farm gate. Thus, in addition to including the final consumers of processed agricultural crops, we include processors of crops such as owners of gins and textile mills. The area under an income-compensated demand curve less associated expenditures is the compensating variation measure of consumer benefits. This measure is commonly termed consumer surplus. The change in consumer surplus resulting from a price change can be seen to be the area graphically bounded by the demand curve and the price axis between the two price lines; this change can be approximated by the change in price multiplied by the average of the quantities associated with the old and the new prices.

Because compensated demand curves are not empirically observable, we approximated consumer surplus with ordinary demand functions. As price changes resulting from alternative boll weevil management programs are rather small, the bias attributed to using ordinary demand functions rather than compensated demand functions appears insignificant.

In calculating the present value of all benefit and cost items, we discounted future benefits and costs with an annual interest rate of 7.125 percent. All annual benefits and costs were estimated in constant 1979 dollars. Thus, one should note that the 7.125-percent interest rate is a real rate and not a nominal rate. The discount rate chosen for this study is the 1980 rate recommended by the Water Resources Council for land and water resource planning. The literature abounds with references to problems in selecting the correct discount rate (for example, (*1*)). However, sensitivity analyses conducted on the discount rate show that the relative ranking of alternative programs is not sensitive to changes in the discount rate used to evaluate the options.

Aggregate Evaluation Results

Evaluation results of interest to policymakers include differences among programs in public cost requirements, average producer net returns, commodity price changes, and net market benefits implied by these component measures.

Compared with CIC, prices received by farmers dropped for all alternative programs (table 3). All

Table 3—Changes in commodity prices resulting from alternative boll weevil management programs and CIC base prices[1]

Commodity	Unit	CIC base price	Change in price resulting from program				
			OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
Corn	Dollars/bushel	2.56	−0.005	−0.005	−0.005	−0.006	−0.008
Small grains[2]	do.	2.71	−.002	−.002	−.002	−.002	−.003
Grain sorghum	do.	2.66	.008	.008	.10	.013	.014
Cotton lint	Cents/pound	76.25	−1.67	−1.67	−1.95	−2.08	−2.73
Cottonseed	Dollars/ton	122.46	−11.65	−11.65	−13.56	−14.40	−19.00
Soybeans	Dollars/bushel	6.46	−.016	−.016	−.013	−.015	−.02
Cottonseed meal	Dollars/ton	168.20	−5.10	−5.10	−5.90	−6.60	−8.30
Cottonseed oil	Cents/pound	36.51	−.99	−.99	−1.15	−1.23	−1.62
Soybean meal	Dollars/ton	185.40	−2.30	−2.30	−2.70	−3.00	−3.80
Soybean oil	Cents/pound	28.57	−.06	−.06	−.01	−.01	−.02

[1]All prices and price changes are averages of estimated values for 1993-95 in 1979 constant dollars. All values reflect longrun equilibrium, after full adjustment to the particular boll weevil management program.

[2]Small grain prices are in terms of wheat equivalents.

prices reflect longrun equilibrium levels after full adjustment to the respective programs. Price decreases resulted chiefly from increases in production or substitution effects among products. The equilibrium base price for cotton lint was 76.25 cents per pound. Price decreases ranged from 1.7 cents per pound for OPM-NI to 2.7 cents per pound for OPM-NI-BWE (table 3).

Net market benefits—a major criterion for ranking alternative programs—were positive for all programs (table 4). The program with the highest net benefit was OPM-NI-BWE, followed in order by OPM-I, CIC-BWE, OPM-NI, and OPM-PI. Net benefits equal the sum of consumer and producer benefits minus public costs. All estimates represent changes from CIC and are based on future streams of benefits and costs discounted at the 7.125-percent rate.

The benefit-cost (B/C) ratio is an alternative measurement for ranking alternative programs that is relevant with a budget constraint. The B/C ratio is calculated as the present value sum of consumer and producer benefits divided by the present value of public costs. The B/C ratio is highest for OPM-NI, followed in order by OPM-PI, CIC-BWE, OPM-NI-BWE, and OPM-I (table 4). The differences in the B/C ratios for OPM-PI, CIC-BWE, and OPM-NI-BWE are probably insignificant.

Net income to cotton producers as a group was negative for all programs. The aggregate impact of lower cotton lint and cottonseed prices exceeded the positive effect of increased yields and lower production costs. Many producers in the major production areas such as the Mississippi Delta, the High Plains of Texas, and the nonweevil-infested areas of the Far West do not directly benefit from the programs included in this evaluation, but they do experience the resulting lower prices. However, producers in heavily infested areas do benefit from these programs. Net income for soybeans, corn, and small grains decreased because of small price decreases and minor changes in the location of production. Grain sorghum returns increased slightly in response to higher prices caused by a shift to cotton in most areas of Texas.

Uncertainties and Implications of the Analysis

The economic analysis reported here relies heavily on biological relationships: (1) yield-infestation and (2) insect control inputs and costs associated with alternative programs for cotton insect management. We estimated these relationships through the interaction of experts in a Delphi process.

A degree of uncertainty in the Delphi estimates arises from two sources. First, precise, scientifically determined data are not available to substantiate the scientific judgment of the Delphi panelists. However, this deficiency is the reason a Delphi approach was used. Second, the standard deviations surrounding some Delphi average estimates, particularly those for lint yield changes in eastern Texas, indicate a relatively

Table 4—Present values of benefits and costs for alternative boll weevil management programs[1]

Group or item	Changes in present values[2]				
	OPM-NI	OPM-PI	OPM-I	CIC-BWE	OPM-NI-BWE
	Billion dollars				
Consumer benefits[3]	4.58	4.50	5.16	4.17	6.46
Net income to cotton producers	−.85	−.84	−.60	−.42	−.96
Net income to other producers[4]	−1.10	−1.09	−1.04	−.84	−1.37
Program costs paid by the Government[5]	.06	.12	.44	.16	.24
Net market benefits[6]	2.57	2.45	3.07	2.75	3.89
B/C ratio[7]	44:1	21:1	8:1	18:1	17:1

[1]Net benefits and B/C ratios are based on unrounded data. Figures in this table represent changes in present values of benefits and costs as compared with a baseline that represents current insect control.

[2]Future benefits and costs are in 1979 dollars, discounted at a 7.125-percent rate into perpetuity.

[3]Consumers include all market participants beyond the farm gate, including processors, millers, and final consumers.

[4]Includes producers of soybeans, corn for grain, grain sorghum, and small grains.

[5]Producers were assumed to pay 50 percent of eradication program costs, exclusive of capital costs and followup monitoring. Producer shares of program costs are reflected in returns to cotton production.

[6]Net market benefits equal the sum of above consumer and producer benefits minus program costs paid by the Government. This is generally considered the best criterion if there are no budget constraints.

[7]B/C ratios were calculated as the sum of the present value of consumer and producer benefits divided by the present value of public program costs. This is generally considered the best criterion if there are budget constraints.

high variance of expert opinion among panelists. Therefore, the economic evaluation included sensitivity analyses of the Delphi data. We ran TECHSIM by using the Delphi estimates of cotton yield changes and also by using yield changes equal to 50 percent of those estimated by the Delphi panel. Comparison of results of these runs showed that reduced yields resulted in lower net social benefits (as would be expected), but they did not alter the relative ranking of the alternative programs (*4*).

The Delphi estimated impacts of OPM-I were made under the assumption that sufficient cotton acreage receives diapause or overwinter control so as to prevent the need for in-season treatment for boll weevils prior to the onset of *Heliothis* on at least 90 percent of the cotton acreage. Similarly, Delphi estimates for both alternative programs for boll weevil eradication were made under the assumption that eradication was successful in the strict sense of reducing the population to zero. The Delphi experts did not address the technical or operational feasibility of eradication as part of the data generation process, but its feasibility would necessarily be part of the program selection process.

Program components and costs were estimated, even though there was little empirical evidence on workability, effectiveness, or producer participation. However, a rigorous review and interaction process was implemented. To a limited degree, the risk of public program cost overruns would be provided for by small contingency funds in the program budgets. There was little research or other information on the rate of adoption or producer participation in voluntary extension programs. Sensitivity analysis provided an estimate of the effects of a 7-year adoption rate for OPM-related programs as compared with the 2- to 3-year adoption rate used in this evaluation (*4*). Again, the ranking of alternatives remained the same, although a slower rate of adoption resulted in slightly lower net benefits.

In addition to the uncertainties mentioned above, it is not known that eradication *per se* is technically feasible regardless of expenditures. Unfortunately, the nature of the boll weevil problem implies that there is no scientific way to assess the probability of eradication short of a complete eradication effort for the United States; then, the probability of success is 0 or 1. Consequently, there is no scientific or

objective way to assign probabilities to estimates of economic effects that appear in this article.

Major Conclusions

All the alternative programs increase consumer benefits at the expense of farm income; moreover, consumers could compensate producers for their losses and still be better off. In an *ex ante* sense, many producers have difficulty perceiving how they would be worse off without the boll weevil; similarly, consumers may have difficulty perceiving benefits attributable to boll weevil management programs. In an *ex post facto* sense, changes in consumer benefits and farm income resulting from a boll weevil program would be concealed by many other factors that influence prices and farm income. Thus, there would be considerable political danger in selling consumers on the idea that they could compensate producers and be better off. For these reasons, compensation appears quite unlikely.

If boll weevil control has a high enough budget priority for any of the programs to be financially feasible and if the decision is to be made without regard to whom the benefits and costs accrue, then OPM-NI-BWE is the preferred program, as it has the highest net social benefits. On the other hand, if boll weevil control is a low priority budget item, the preferred program is not clear unless it is compared with many other possible investments of public funds. With budget constraints, greater importance should be given to the B/C ratio than to net social benefits. Using a B/C ratio criterion indicates that OPM-NI is the preferred program even though it has the next to the lowest net social benefits.

From the long-range perspective of agricultural producers, CIC is the preferred program option because aggregate farm income is highest under current boll weevil management methods. Although producers in heavily infested regions would gain from any of the programs evaluated, the gainers cannot compensate the losers and still be better off.

Given the results of this study, the choice of the "best" boll weevil management program depends on the target group for program implementation.

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The Economic Research Service: 22 Years Later

By Willard W. Cochrane*

Abstract

In this solicited article, Willard Cochrane, the U.S. Department of Agriculture's first Director of Agricultural Economics, assesses the mission, performance, and organization of the Economic Research Service (ERS) 22 years after its establishment in 1961. The current organization is satisfactory, and the agency has done an excellent job providing information on past trends, current situation, and short-term outlook. It has been less successful in anticipating important problem areas. Although ERS has a reservoir of good will among its clients, it does not have the hard support that interest groups sometimes give their companion Government agencies. Its future depends on providing quality economic intelligence that will cause its clients to view ERS as indispensable. Future problems may relate to funding, recruiting, and defining the Agency's role with respect to the Office of the Secretary of Agriculture.

Keywords

Economic Research Service, policy, U.S. Department of Agriculture

The various economic and statistical units that had been scattered across the U.S. Department of Agriculture (USDA) in the fifties were drawn into one grouping under my direction in the winter of 1961. They became the Economic Research Service, the Statistical Reporting Service, the Staff Economists Group, and the Management Operations Staff. I described the reorganization that brought this grouping into being in this journal in July 1961. With the advantage of some hindsight, I described and appraised it in the *Journal of Farm Economics* in May 1965 under the title, "Some Observations of an ex-Economic Advisor: Or What I Learned in Washington."

Speaking specifically now with regard to ERS, we recognized at the time that putting together all the economics work of USDA into one service would leave it exposed to, and vulnerable to, numerous kinds of attacks. Disgruntled bureaucrats who lost units to the new ERS could be expected to engage in maneuvers, over time, to have those units returned to their agencies. A relatively large economics service without a large and powerful clientele base could get chopped into little pieces by the budget cutters, both in the Administration and in the Congress. And, there were powerful enemies of economic analysis and planning lurking about in USDA and the Congress dating back to the forties when the Bureau of Agricultural Economics (BAE) was the chief planning agency of the Department. They were just waiting to pounce on it, if and when the new service made its first blunder. But we went ahead with the consolidation of the economics work because we believed that the advantages outweighed the risks. The *esprit de corps* of the dispersed economic workers in USDA, as of January 1, 1961, was at a low ebb and we knew that their morale would be raised by bringing them together into one agency that understood and appreciated their efforts. We believed that such a consolidation with the increased intellectual interaction that would result would increase the workers' productivity and would improve the quality of their work. And we were convinced that sectorwide, or industrywide, studies could be conducted more expeditiously and more effectively where all the subbranches of the economics discipline were under the same administrative roof. Thus, the Economic Research Service was created.

Now in the winter of 1982-83, I have been asked to take another look at ERS—to appraise its past per-

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formance, to discuss its problems, and to peer into the future to see what it holds for the Agency. I am pleased to have this opportunity because I believed that the organizing actions that we took in the winter of 1961 were good and proper, and I have always viewed ERS as one of the really strong economic research agencies in the Federal Government. Thus, some will say that this review and appraisal has to be biased. Perhaps it is. But if it is, readers will know the direction of that bias.

Before we can appraise the performance and make judgments concerning the future of ERS, we must be clear as to what it should or should not be doing-that is, what its proper mission is. And, we must be clear as to its organizational capacity to achieve its mission—that is, what its organizational structure is and how it functions. With regard to the first point, there is much misunderstanding and confusion. With regard to the second point, reorganization is an endless process in the Federal bureaucracy. Thus, it is important that we have a good understanding of the nature of the agency that we intend to scrutinize.

Mission

What is the proper role of ERS? On this question there is little agreement. Agricultural economists in academic institutions most often express the view that ERS should look and act like a collegiate department of agricultural economics, except that ERS is much larger and has no teaching responsibilities. In this view, the need for mission-oriented research, intelligence gathering, and dissemination is given low priority. The right of each staff member to have complete freedom in the choice of research projects and the conduct of that research is given the highest priority. In this view, a strong ERS is a collection of highly qualified, highly motivated economic researchers, each doing his or her own thing.

A new administration is likely to take a very different view of ERS. It is likely to look upon ERS as its private staff agency—one that can first help it sort out the economic consequences of alternative courses of action and can then help it develop logical and quantitative arguments in support of its policy decisions. In this view, ERS would come and go with administrations.

The congressional view of ERS is not so easy to define. There are probably as many viewpoints as there are members of the Congress. But this much is certain: any research results produced by ERS that reflect negatively on a member's constituents will incur the wrath of that member. That is what happened in the forties. Certain sociological studies undertaken by the BAE reflected negatively on some rural communities in the Deep South; as a consequence, members of the Congress from those areas did not rest until the BAE was dismembered. But, it is also the case that each member of the Congress expects ERS to provide him or her promptly and cheerfully with information, data, and possibly a special report upon request. ERS is an important staff agency to the Congress.

Finally, ERS receives a steady stream of requests from farmers, farm leaders and their organizations, agribusiness firms, trade associations, food and nutrition organizations, church groups, students of all ages, teachers, and college professors for information, data, and reports. ERS serves as the basic intelligence source regarding the food and agricultural sector, worldwide, for our diverse national publics.

Thus, it is clear to me that the proper role of ERS is that of a staff agency. But, a staff agency to whom or what? In my judgment, ERS should be viewed as a staff agency to the Nation. It must be prepared to respond regularly and effectively, without compromising itself, to the economic analytical needs of the Office of the Secretary; it must understand and appreciate the intelligence needs of members of the Congress and find ways of satisfying those needs without coming into conflict with the administration in power; and it must recognize and anticipate the information and intelligence needs of a diverse national public and develop effective channels for meeting those diverse needs.

This set of staff activities represents no small order. To the academic who values complete freedom above all else, the staff agency role may seem demeaning. But is it? Certainly the role is different from that of an academic researcher. But, it is no less demanding in terms of analytical skills.

Let us consider briefly the substance of ERS staff work. The agency must:

1. In conjunction with the Statistical Reporting Service (SRS) and other agencies in USDA, refine and publish regularly all kinds of primary data for States, the Nation, and the

world relating to the food and agricultural sector (for example, production, stocks, and prices).

2. Conceptualize, compute, and publish all kinds of economic indicators (for example, parity price, resource productivity, and farm income).

3. Estimate, sometimes regularly, sometimes upon request, with the aid of research techniques ranging from simple estimating equations to nationwide econometric models, the impact of important independent variables such as the gross national product (GNP) on various agricultural variables (for example, farm prices or the consumption of beef).

4. Describe and analyze important institutional developments in the food and agricultural sector (for example, the family farm, milk marketing orders, the food stamp plan, and the structure of the fertilizer industry).

5. Monitor resource use developments (for example, the expanding rural-urban fringe, the effect of soil erosion on productivity, and the increased competition for scarce supplies of water), anticipate and analyze problem areas, and be prepared to make policy recommendations.

6. Describe the many sides of domestic rural development, identify and analyze its many problems, and be prepared to make policy recommendations.

7. Simulate the international markets for agricultural commodities and estimate volumes of trade, international market price behavior, and the direction of product movements.

8. Monitor and analyze developments in the Third World and anticipate food aid requirements, as well as other kinds of developmental needs.

9. Anticipate, define, and analyze problem areas in the food and agricultural sector at home and abroad (not covered above) that will require policy decisions in the years ahead.

The substantive areas outlined above and the activities and projects that fall within them are all aimed at providing decisionmakers in the food and agricultural sector with information and intelligence bearing on those decisions. The leadership and the professional staff of ERS cannot decide one day that they will delete one of these substantive areas and add, say, an area concerned with organic farming. The information and intelligence needs of decisionmakers in the food and agricultural sector determine the working agenda of ERS. But the leadership and professional staff of ERS have all the freedom that they can use in selecting specific projects, in developing and employing analytical techniques, and in developing the means of disseminating information and intelligence. Thus, although the working agenda of ERS is determined in broad measure by the needs of the diverse publics which it serves, there is much room for research creativity and innovative ideas.

Organization

The reorganization that created ERS in 1961 divided the work of the agency into two principal groupings: domestic and foreign. The economic research agency of USDA for the first time placed emphasis on international developments and on the need to provide reliable information on those developments and relevant analyses of them. The domestic grouping was assigned to three divisions: economics and statistics, farm economics, and marketing economics. These were conventional units at that time and each continued the traditional kinds of economic work known in USDA. In the reorganization of 1961, human and social problems were played down and land and water resource problems did not receive a high priority. The first organizational decision was necessary for political reasons; the second resulted from the blind spots of those responsible for the reorganization, namely, me.

Since 1961, ERS like most agencies in USDA, has undergone numerous reorganizations, some minor, some major. In the early seventies, under one administration, a strong effort was made to eliminate formal organizational units below the division level. All the research personnel and work were assigned to temporary research program areas, each headed by a team leader and each area to disappear upon completion of the research program. In the late seventies, under another administration, the work of the Economic Research Service, the Statistical

Reporting Service (SRS), and the Farmer Cooperative Service was combined into one service—the Economics, Statistics, and Cooperatives Service (ESCS). Then, ESCS became ESS—the Economics and Statistics Service—when the cooperatives unit was split off as the Agricultural Cooperative Service. Under the current administration, ESS was dissolved to recreate ERS and SRS. Fortunately, these reorganizations passed without doing too much harm to the work of ERS.

The current organization is described graphically in figures 1-5. In the judgment of this writer, this organization is a good one. The various organizational boxes and their descriptive titles suggest two important things: first, ERS has the organizational coverage to deal with all the important economic and social problems that might arise in the food and agricultural sector, worldwide; and second, it has the organizational capacity to produce the information and analyses (both economic and social intelligence) required under the nine substantive areas outlined earlier in this article. Of course, whether it performs as required in those areas will depend on: (1) the quality of its leadership, (2) the skill and creativeness of its professional staff, and (3) the financial support which it receives.

Performance

How has ERS performed since 1961? From discussions I have had with past directors of agricultural economics, I reach the conclusion that ERS has performed exceptionally well as a staff agency to the Office of the Secretary. This does not mean that all has been smooth sailing. The proper staff relation of ERS to the Office of the Secretary has not, I believe, yet been developed. But this failure rests as much in the Office of the Secretary as it does with the leadership of ERS. Some administrations have made little use of ERS in its staff capacity; others have treated it as their own private staff agency. Through all this, ERS has delivered the economic intelligence basic to rational decision-making in the Office of the Secretary. No Secretary of Agriculture since 1961 need have been in the dark regarding the consequences of decisions by his agricultural administration if he had made proper staff use of ERS.

It is somewhat more difficult for an observer from the hinterland to judge how effective ERS has been as a staff agency to the Congress over the past 22 years. But since I have heard of no big flareups and since I know personally of the efforts of Nathan Koffsky and M. L. Upchurch, former administrators, to provide congressional committees and members of the Congress with effective staff work, I would judge that the performance of ERS in this regard was at least adequate and perhaps excellent.

With regard to the performance of ERS in providing staff work to the diverse publics of the national society, I should like to consider two different aspects of that work. First, it is difficult for me to see how ERS could have done a better job in recent years in providing those publics with relevant refined data, economic indicators of all kinds, and short-term outlook and analyses than it has. Publications such as *Agricultural Outlook*, *World Agricultural Supply and Demand Estimates*, and *Economic Indicators of the Farm Sector* and the information and data they contain are excellent. No doubt there is room to improve the reliability of the published data and estimates, particularly the foreign data and estimates. There always is. But the diverse American publics are blessed with excellent economic intelligence with respect to past trends, the current situation, and the short-term outlook for the food and agricultural sector worldwide.

Second, ERS has been much less successful, in my judgment, in anticipating, defining, and analyzing important problem areas in the food and agricultural sector at home and abroad that require policy decisions now and in the years ahead. There has been a leadership failure in this respect. I refer here to division heads, section heads, and senior professionals as well as administrators and their deputies. The general public has received little in the way of insightful guidance from ERS with respect to future problem areas of importance.

There may be any number of reasons for this failure: (1) the natural timidity of bureaucrats in their quest for survival, (2) the preoccupation of the leadership of ERS in the seventies with reorganizations, (3) the increased specialization in the agricultural economics profession generally and the drive on the part of individual researchers to learn more and more about less and less, and (4) the lack of any generally ac-

Figure 1

Organization of the Economic Research Service

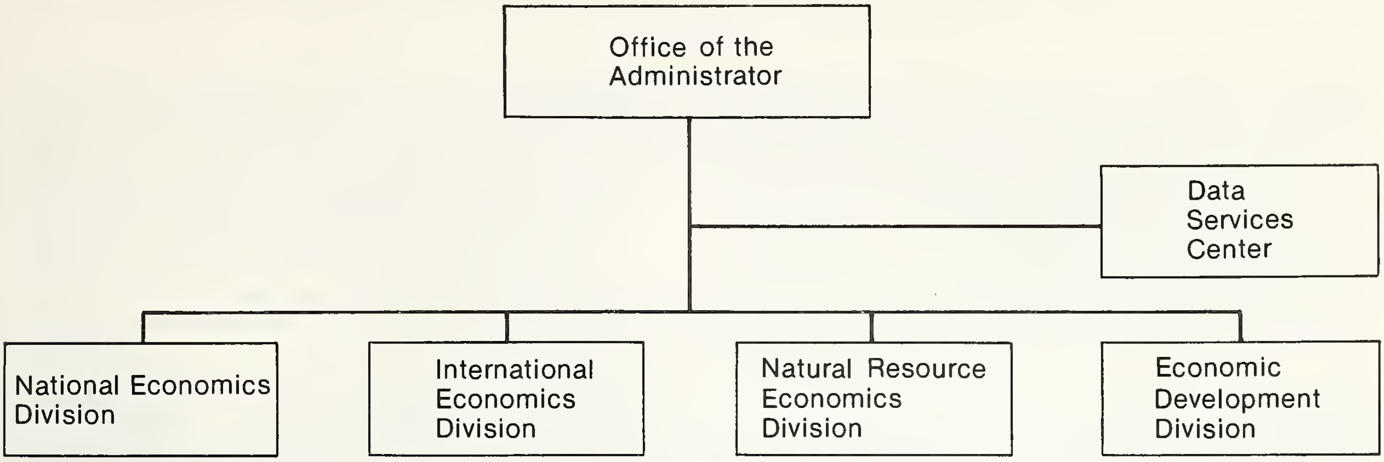


Figure 2

Organization of National Economics Division

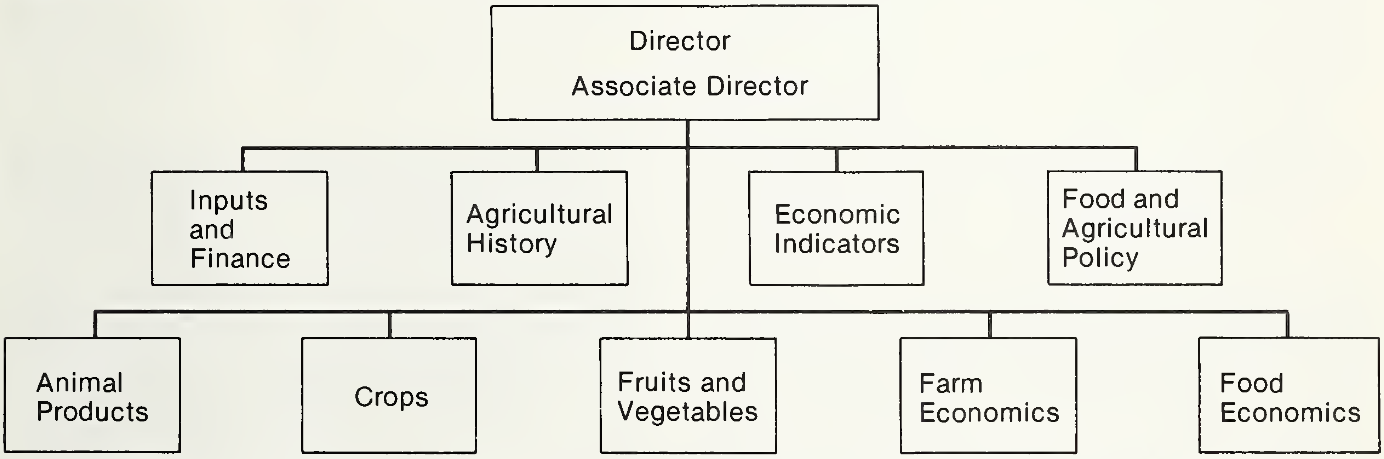


Figure 3

Organization of International Economics Division

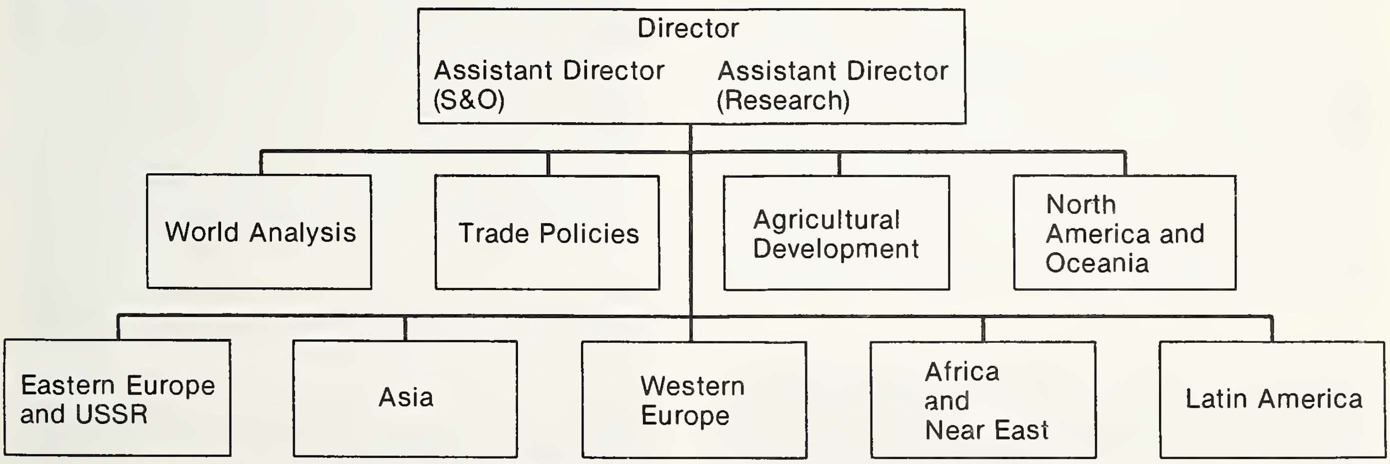


Figure 4

Organization of Natural Resource Economics Division

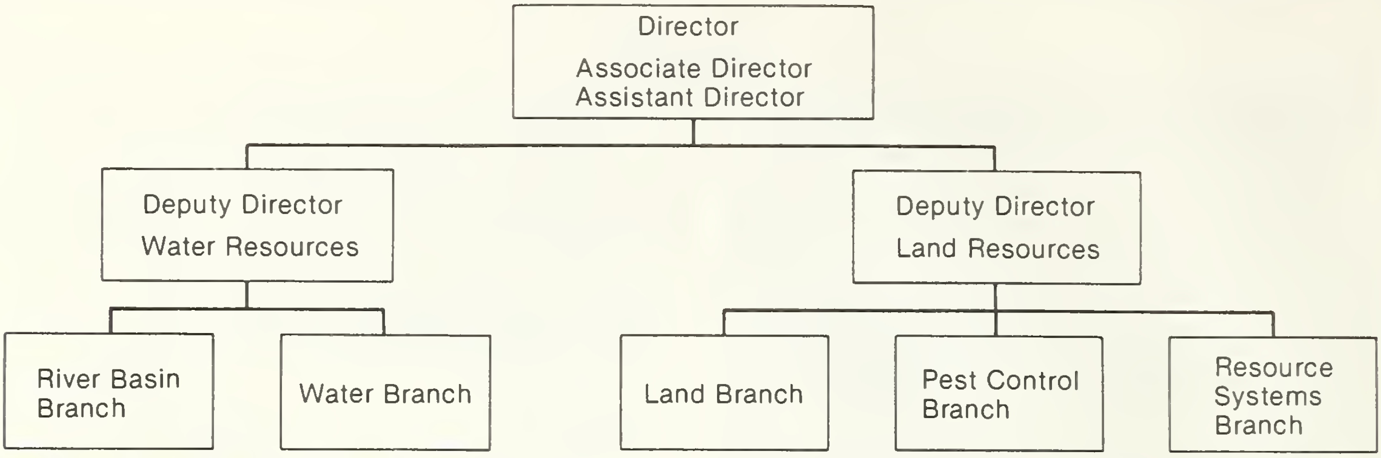
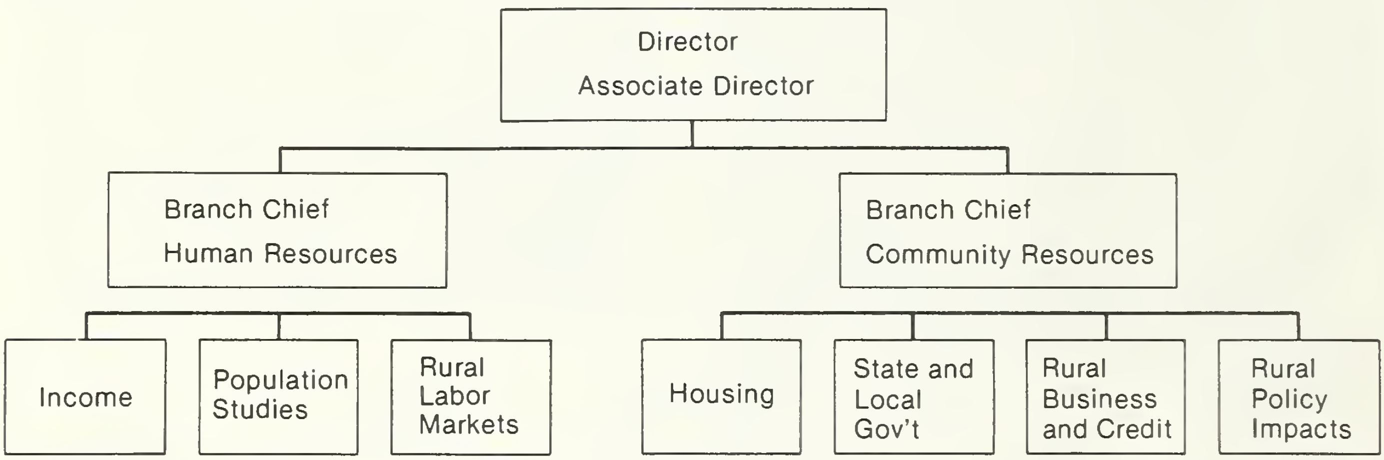


Figure 5

Organization of Economic Development Division



cepted theory regarding the development of American agriculture.

But, on occasion, ERS has attempted to take an intensive look at emerging problems. In the early seventies, the agency made projections of world food supply and demand to 1985 and then undertook to define and describe the problems that could emerge. The study identified certain prospective food problems, but it was more or less a projection of the conventional wisdom of the time and failed to have any significant impact.

In the late seventies, the Office of the Secretary pushed ERS into an intensive study of the changing structure of American farming. One publication that resulted from that study, *Another Revolution in U.S. Farming?*, had an eye-catching title and did a good job of describing the changing structure of American farming with the attendant increased concentration of productive resources into the hands of fewer and fewer and larger and larger farmers. It also listed a number of forces which have contributed and continue to contribute to this concentration. But one does not come away from this report with either an operational explanation for the continued concentration or a feel for what society might do about the development, if anything. A more insightful report, *A Time to Choose*, issued by the Office of the Secretary, but based in large measure on ERS research, got caught in a change of administrations and failed to have a significant impact.

ERS has made an effort in the past, but it continues to fumble with its staff mission of anticipating, defining, and analyzing important prospective problems

of food and agriculture. Either through timidity or lack of vision, it has not provided the diverse American publics with the insights which they require regarding emerging problems in the food and agricultural sector to think constructively about those problems and then to make rational decisions.

Problems

Every organization has its problems. Let us now look at specific problems confronting ERS. Because ERS has no hard-core clientele group (for example, the milk producers or the wheat growers) to support it in its budget battles on Capitol Hill, it has chronic budget problems. Basically, it depends on the largesse of the political administration in power and the general good will of a large number of interest groups and publics. This is uncertain support at best, and it can crumble fast in the face of stiff opposition.

As a consequence, the total funding support of ERS, in real terms, has declined modestly, but steadily, since 1978. The total number of professionals in ERS has declined steadily and significantly since 1975. Assuming that the average quality of the professional staff has not changed over this period, ERS has significantly less capacity to achieve its missions in 1983 than in 1975. A continued erosion of funding support and professional staff will damage ERS severely. Thus, the chronic budget problem of ERS is approaching a critical stage.

Related to the budget problem is the relationship of ERS to the Office of the Secretary, since ERS is so completely dependent on the initial budget decision in the Office of the Secretary. I have argued earlier that one of the important staff functions of ERS is providing economic intelligence and analysis to the Office of the Secretary. How well ERS performs in this function can have two important consequences: first, it may determine the success or failure of the economic policies of the administration in power; and second, it may determine how generous the Office of the Secretary will be in its funding support for ERS.

But, this relationship is not determined solely by the actions and responses of ERS. It takes two to tango. Some Secretaries of Agriculture make little or no use of ERS staff work. They prefer to lean on personal intuition and economic ideology. Other Secretaries seek to monopolize the time and personnel of ERS in providing staff work for their administrations. Henry Wallace even made the BAE the central planning agency of USDA. This policy was a disaster. Once the principal economic agency of USDA becomes identified as the author and proponent of the economic policies of an administration, it must rise and fall with that particular administration.

The problem confronting each administrator of ERS and his lieutenants in this delicate bureaucratic relationship area is the following: how to be an effective staff unit to the Office of the Secretary (that is, how to provide that office with the economic intelligence and analysis required to make rational economic decisions) without becoming closely identified with the specific policies and programs of that administration. The successful administrator of ERS must maneuver the agency along a narrow edge in which ERS provides the Office of the Secretary with the "right" amount of good economic staff work, but in which ERS does not become a captive of that particular administration. And, that is no easy task.

In this connection, the new Economic Analysis Staff (EAS), which is much like the former Staff Economists Group, should contribute to a stable and productive relationship between the Office of the Secretary and ERS. As may be recalled, the Group was comprised of three to five policy-oriented economists who, under the direction of the Director of Agricultural Economics, were engaged in policy formulation and program planning. Such a unit had two important advantages for ERS. First, it provided personal contact points in the Office of the Secretary that could define the type of staff work needed from ERS and then effectively use the staff work provided. Second, it provided a buffer between the political activities in the Office of the Secretary and the ongoing staff work of ERS. But creation of EAS is not the responsibility of ERS management; it is the responsibility of the Assistant Secretary in charge of economics. ERS leadership can, however, promote the idea whenever the opportunity arises, and certainly, it should not oppose the idea.

The Economic Research Service, like any "think tank" or research unit, has a continuing problem of locating, hiring, and holding highly qualified, highly motivated professional workers. There is, however, a

special problem in the area of agricultural economics, and possibly in other areas of economics as well. The big name graduate schools in agricultural economics are not interested in turning out graduates to work in a mission-oriented staff agency. Those schools are interested in turning out highly trained, highly specialized research workers who seek to ply their trade in discipline-oriented situations. Thus, the top students in the top graduate schools are seeking positions in other big name graduate schools where teaching loads are light and where they have great freedom in using their sophisticated skills in a highly specialized research category. Note, I did not say using their sophisticated skills on important economic problems. I said, and I repeat, using their sophisticated skills in a highly specialized research category.

In such a graduate training environment, where are the administrators of ERS going to find highly qualified, highly motivated professional agricultural economists to work in their mission-oriented staff agency? The recruitment of such young professionals is not, and will not be, easy. Several not too promising options are open to administrators. They may recruit graduates at the Master's level who have acquired certain technical research skills and train them on the job to be effective staff economists. Or they may, with considerable effort, locate graudate students who are unhappy with their current graduate program, with its heavy emphasis on specialized, disciplinary research, and who would like to escape to where the action is. Such students are generally viewed as malcontents and are likely to get poor recommendations from their professors. Or, they may hire graduates from less prestigious schools (who may be late bloomers and very bright) and mold them through on-the-job training into effective staff economists. But this latter approach has limitations, as there is now a tendency for the less prestigious schools to try to out-do the prestigious schools in research methodology and discipline-oriented research. In short, then, there are ways to beat the present day graduate training game plan, but the recruiters will have to work hard and know what they are doing to succeed.

This problem can be illustrated and perhaps even be dramatized by reference to the contents of the October 1982 issue of *Agricultural Economics Research* (AER). Each of the four articles in the October issue would be judged, by current standards, as pieces of high-quality research. They are also highly specialized; they emphasize technique developments, and they are discipline- rather than problem-oriented. One of them might well win a prize as an outstanding piece of research. And the author of one of them might receive an offer of a tenured position at a big name university. But John E. Lee, Jr., is not going to receive any help from the October issue of AER in his struggle to increase the funding support for ERS before the House Subcommittee on Agricultural Appropriations. Secretary Block is not going to receive any help from the October issue in dealing with the surplus problem that now confronts him. The beef producers are not going to receive any help in making production adjustments to deal with changes in consumer tastes and preferences for beef. Church groups are not going to learn how to acquire and distribute American farm surpluses to the downtrodden at home and abroad. And medium-sized commercial farmers are not going to receive any guidance as to whether they should sell out now to their large aggressive neighbors while they still have some equity in their places, or fight the often losing battle a while longer.

Now the authors of the articles in the October issue of AER can say with justification: "We were not trying to answer such questions in those research efforts. We were trying to advance the science of agricultural economics." And that they were. But Secretary Block, Jamie Whitten, or I can also ask with justification: "Who is going to combine these four specialized pieces of disciplinary research with the hundreds more that are being produced across the Nation in our institutions of higher learning, together with vast amounts of data that are available, together with the institutional developments that must be taken into account, to provide answers to the types of questions raised above?" The older professionals who have done this kind of integrating work are becoming a scarce commodity. And the graduate schools are turning out a graduate product that, for the most part, is not interested in such a nonelegant integrating activity.

So, it turns out that ERS does have a serious staffing problem. Where is the leadership of ERS going to find highly qualified, highly motivated, problem-oriented economists willing to spend a lifetime in a staff agency like ERS? Somehow, somewhere the

leadership must find such professionals or the agency will be in trouble, deep trouble.

Future

What of the future? ERS is here to stay, I think. In its role as a staff agency to the Nation, ERS has supplied economic information, intelligence, and analysis over the past 22 years to a wide range of people and groups: the Office of the Secretary, members of the Congress, Washington-based consultants and interest groups, farm organizations, State extension workers, teachers from grade school to graduate school, agribusiness firms, church groups, individual farmers and individual consumers, and a wide range of international groups and organizations. From my reading of the past performance of ERS as an economic staff unit to a wide array of persons, groups, and organizations, I conclude the following. Most of these people, groups, and organizations feel that ERS has done a good job, but that it could do better. Thus, there is a large reservoir of good feeling in the Nation and the international community for ERS. But this reservoir of good feeling does not represent hard-core support for ERS such as numerous special interests provide for their companion Government agencies (for example, the National Association of Conservation Districts for the Soil Conservation Service).

This reservoir of good feeling is something that can be built upon, but as of 1983, it does not represent a force which could save ERS if or when the crunch comes to dismember the Agency. I don't predict with any degree of probability that such a crunch will come, but there is always the chance that it will. There is always a chance that a Secretary of Agriculture will come to office with strong populist leanings who holds all intellectual activities in contempt, and who would seek to destroy ERS and all its works. There is always a chance that a Secretary of Agriculture will come to office from the far right who holds the view that the only legitimate role of Government is to provide police and fire protection, preserve the sanctity of contracts, and perhaps provide some indirect subsidies to very large farmers, and who would take actions to weaken or destroy ERS. And, there is always the chance that some published piece of economic intelligence or analysis would infuriate some powerful special interest group and cause that group to use its power both in the Administration and in the Congress to destroy ERS. In these and possibly in other ways, there is always the chance that a crunch will develop in which ERS is either seriously weakened, dismembered, or totally destroyed.

In the judgment of this writer, the future of ERS depends upon how the leadership and the professional personnel of ERS perceive their Agency. If they hold the view that the provision of economic information, intelligence, and analysis to the Nation is important, then they will be motivated to do high-quality staff work and the chances are good that their staff work will, in fact, be of a high quality. In this connection, I have in mind more than the willingness of a few professionals to run a computer printout over to the Office of the Secretary late on a Friday afternoon; I have in mind the perception on the part of all ERS professionals of the importance of all research activities outlined under the nine points in the second section of this article.

If, further, the leaders and the professionals of ERS hold the view that doing staff work is exciting, which it can be, then the chances are good that they will be creative in their staff efforts and that their final product will be of excellent quality. Where this is the case, we can expect the good will toward ERS on the part of the many and diverse publics and clientele groups to metamorphose into a feeling that the work of ERS is *indispensable* to their activities and operations. In such an atmosphere, ERS may expect to survive and prosper because such a strong feeling on the part of those relying on the staff work of ERS cannot help but be transmitted to the budget decisionmakers in the Administration and in the Congress.

But, if the leaders and professionals of ERS hold the view that staff work is drudgery that must be endured (as teaching is often viewed in universities) to win the free time to undertake specialized, discipline-oriented research (that they hope will be published in some learned journal and thereby win for the authors the plaudits of their economist peers), then it is certain that ERS staff work will be of mediocre quality and will be so viewed by user groups. In such an atmosphere, the future of ERS is not bright. The current good will toward ERS will wither away, and

if and when the crunch comes to dismember or destroy ERS, there will be little or no support for it. ERS has never had a special interest group to fight its budget battles, and in the scenario under consideration, the general support for ERS would be too weak to make any difference to those wielding the dismemberment knives in Washington.

In conclusion, the future of ERS belongs to the leaders and professionals within it. As of 1983, the Agency has an observable base of good will on which to build. But, this base is soft; it does not represent a power base which can be used to expand the activities of ERS in the next few years and to protect it in periods of adversity.

How then is ERS to build on its base of general good will? It must do so in the same way that such a base was created in the first place. It must provide economic information, intelligence, and analysis to the diverse clientele groups in such forms and at such times as meet the needs and expectations of those groups and publics. The leaders and professionals of ERS must become so proficient in providing staff work to the nation that such staff work becomes *indispensable* to the operations and activities of its diverse clientele groups and publics. In such an atmosphere, there will be no question about the survival of ERS. In such an atmosphere, it will grow and prosper. And, it will grow and prosper because it is providing a much needed service.

Research Review

The Value of Agricultural Land in the United States: A Report on Research

By John P. Doll, Richard Widdows, and Paul D. Velde*

In view of a long history of increasing land prices followed by recent downward adjustments, the question arises: Is farmland overpriced or underpriced in relation to earnings? The answer is important, but the rationale behind the answer is equally important. We have prepared five reports on the subject of land values. The reports include a review of the literature (*6*), an updating and re-estimation of some econometric models of the land market (*22*), estimates of returns to assets in 10 farm production regions (*5*), a descriptive analysis of cash rents (*4*), and some concluding thoughts (*3*).[1] In this article, we present a brief abstract of our literature review and summarize our empirical studies of the econometric models and imputation procedures.

Literature Review

Most research published since the fifties has been directed towards answering one or more of three questions: What are the earnings of farmland? What economic forces affect the price of farmland? Is farmland overpriced or underpriced? The early literature often appealed to the theory of the firm in pure competition—that is, to an evaluation of farmland's marginal value product in the short run and its factor share in the long run. In either case, the question asked was: Are earnings of the input within the firm large enough to justify the market price of the input?

In 1960, Scofield (*17*) noted that land prices were diverging from farm income trends and coined the phrase "land-price paradox." Others echoed these concerns. Two implicit assumptions underlay much of the thinking at that time: (1) farm income per acre is the appropriate variable against which to measure land value, and (2) the traditional valuation formula, $V_e = R_1/d$ (V_e equals present value of an input that earns R_1 dollars per year, given a discount rate of d percent per year), is the appropriate equation for computing the present value of the land asset. This model assumes that land earnings will remain constant at R_1 in perpetuity.

Faced with the paradox of land prices that diverge from farm income trends, researchers looked for alternative explanations. A host of new variables was suggested. New production technologies increased efficiency by lowering costs and creating economies of size. Farm programs maintained prices in the face of these new efficiencies. Expansion of existing farms shifted demand. Demand for land for urban expansion, rural living, highways, and airports decreased supplies of farmland, with the overall effect of increasing prices.

Those who believe in the classical argument of David Ricardo, later espoused by Sir Colin Clark (*1*), that land value must derive from net rent might argue that the above factors increase net rent and thereby increase value. Thus, the search was for new variables that affect net rent—the same old Lorelei in new raiment. Two new explanations did arise. One suggests a problem not resolved in traditional economic theory—the combination of production value and consumption utility in the same resource. Thus, Martin and Jefferies (*13*) attributed a component of demand for land in Arizona to "ranch fundamentalism" or "conspicious consumption" of the western way of life. The second, suggested by Hathaway (*9*) in 1957, was capital appreciation. Hathaway noted that ". . . it is possible for a farmowner who has never enjoyed a high annual income to accumulate substantial assets . . . ." Over the years, Hathaway's measures were refined into the "real capital gains" presented by Melichar (*14*) in 1979. As real capital gains continued to accrue, writers suggested land prices would increase because additional investors would be attracted to the market.

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

Whereas the literature of the fifties and sixties tended to stress the search for new variables and the policy implications of increasing farmland values, more recent research efforts have attempted to clarify the manner in which land earnings are defined and are translated into land values. In the seventies, the assumptions of the traditional capitalization formula were replaced by more sophisticated assumptions. The models proposed incorporated variables to represent inflation, income and capital gains tax rates, finite planning horizons, efficiency and farm size, income variability, and risk aversion (*6*). In 1979, Melichar (*14*) noted that returns to assets were growing, and he used the constant-growth earnings model, which assumes that present earnings will grow at a constant rate, g, into perpetuity. The valuation formula for this model is $V_e = [R_0(1 + g)/(d - g)]$, which implies that low annual returns would be expected when growth rates are large. ($R_0(1 + g)$ equals R_1 of the traditional valuation formula.)

The traditional literature usually relied on partial equilibrium models that considered farmland in isolation from other markets in the economy. Feldstein (*7*, *8*) developed a portfolio demand model that considers farmland as an investment relative to other assets such as gold or bonds. Feldstein's model suggests that in inflationary periods land prices will rise in relation to prices of other assets.

In sum, the results of attempts to determine whether the land market tends to overvalue or undervalue land remain inconclusive. Many studies have addressed single issues involved in the valuation of farmland, but none has assembled a complete picture of farmland as a productive input, a consumption good, and a speculative portfolio asset.

Econometric Models

Following our review of the literature, we updated four econometric models of the market for farmland. Data series originally used in the models were duplicated and extended to 1978; the models were then re-estimated for the entire period for which data were available as well as for selected subperiods (*22*). The models we selected were published by Tweeten and Martin in 1966 (*18*), Herdt and Cochrane in 1966 (*10*), Reynolds and Timmons in 1969 (*16*), and Klinefelter in 1973 (*12*). In contrast to a 1979 study by Pope and others (*15*), who evaluated the usefulness of the models for forecasting, we evaluated the stability of the structural coefficients.

All models included a selection of variables from the general set of factors thought to affect farmland price; many of the same ones have been discussed in the literature review above. Model specifications, however, were quite different and included a partial adjustment model, a recursive model, a jointly determined supply and demand model, and a single equation model; the last could be interpreted as one equation (for price) selected from a set of unrestricted reduced-form equations. Thus, efforts to specify econometric models would appear to be hindered by the lack of an appropriate theory to describe the workings of the land market; that is, no underlying optimal theory was available to explain land values. A detailed analysis of these models is included in our literature review (*6*).

Our results suggested that the structural coefficients were unstable when models were re-estimated for periods beyond or within the time periods for which they were originally estimated. Coefficient estimates often switched signs or became insignificant. To illustrate, we will present some results for the equation of greatest interest here and the one present in all the models in some form—namely, the land price equation. Table 1 lists the general types of variables selected for inclusion in these equations and the frequency of the *a priori* appropriate sign on the estimated coefficients. Variables were represented by different proxies in different models, except for transfers, lagged price, and parity. The data in table 1 suggest that capital gains and net earnings performed best when judged by the criteria of expected sign, whereas transfers and interest rates were least successful.

The poor results partly reflect the significant data problems that confront land market modelers. The land "price" series is not the selling price, but is a value series estimated by U.S. Department of Agriculture (USDA) market observers (*20*). Transfers must be used to represent the quantity variable. Only about 3 percent of the total quantity of farmland is transferred each year in the United States, and no standard measure of the productive capacity of the transferred land is available. Problems of a similar nature plagued other variables, some of which were represented by a variety of proxies.

Table 1—Variables used to explain farmland price in 26 equations from four econometric studies of the U.S. farmland market

Variable	Total appearances	Times sign correct	Times sign incorrect	Percentage of times correct
		Number		*Percent*
Quantity of land	11	8	3	0.73
Size of farms	21	16	5	.76
Transfers	26	14	12	.54
Net earnings	17	15	2	.88
Interest rates	22	11	11	.50
Lagged price	9	6	3	.67
Productivity	6	4	2	.67
Parity	6	4	2	.67
General price level	9	7	2	.78
Government payments	13	9	4	.69
Capital gains	12	11	1	.92

Source: (*22*, tables 6, 9, 13, and 16). Equations were examined over the longest time periods permitted by the data.

Specification problems coexisted with data problems. Lacking a commonly held theoretical basis for determining the effects of land earnings on land values, researchers tended to include a mixed collection of variables in their models. If land values are determined by land earnings and if those earnings are properly measured and appropriately specified in the model, then the inclusion of secondary variables that increase or decrease land earnings is redundant. That is, if technology, farm expansion, Government programs, population, mortgage interest rates, and general economic prosperity increase earnings, then their effects will be properly reflected through earnings. Inclusion of these variables in a model along with earnings would be an error in specification. Thus, while one concern has been whether appropriate proxies could be identified to represent factors affecting land values (*22*), another concern is whether or not any of the factors mentioned should be entered individually in the models. Structural changes as well as specification errors may have also contributed to the disappointing performance of the models.

Although all models used national aggregate data, it is, in fact, difficult to conceptualize an aggregate market for farmland. Land transactions are not made in a setting of pure competition. For reasons developed in our concluding report, we believe a "price leadership" model might be more appropriate (*3*). The product sold is not homogeneous, and the price per unit differs among buyers. As a result, aggregate data represent accounting totals and undoubtedly provide useful descriptive information, but they do not represent market signals that are equivalent to those obtained from crop or livestock markets. Econometric models may be more appropriate in local areas which have greater homogeneity.

Returns to Production Assets

Although the search for "factors influencing land values" was often heuristic and was sometimes based on value judgments about the nature of the market, one avenue of the search was empirical—the imputation of returns to agricultural inputs. One study was published by Johnson as early as 1948 (*11*), and similar studies have appeared since with regularity. USDA researchers have been particularly faithful.

Most imputation studies begin in the same manner, by deriving a gross return from aggregate revenue and cash expense data. The process of allocating this return is where the differences arise. Some resources used in agriculture do not have clearly determined market prices, and many inputs (including land) are durables. Only one input can be the residual claimant in the imputation process.

Some researchers, interested in labor and human capital, imputed returns to land based on cash rent or interest rates on mortgage debt, and they re-

garded labor as the residual claimant. Others valued labor at market rates and imputed returns to land. Some were particularly cautious and did both.[2] Melichar (*14*) rejected the already battered notion that net farm income should be considered the primary determinant of land values and instead estimated the returns to all production assets in agriculture. As Doll and Widdows (*2*) show, the constant growth earnings model, when applied through time according to Melichar's suggestion, implies that the growth rates in asset values should equal the growth rate in asset earnings. Melichar concluded this was generally true in agriculture for the 1950-78 period and that asset earnings do support the capital gains experienced in agriculture.

We applied Melichar's test to regional data and supported his conclusions for 8 of 10 regions throughout the 1950-78 period, but supported them for fewer regions in the fifties and sixties. Following the techniques developed by Evans for the *Balance Sheet of the Farming Sector* (*19*), we estimated the value of productive assets and the residual earnings of assets in 10 U.S. farm production regions for 1950-78 (*5*). (The 10 production regions are defined by USDA.) Our report presents the techniques used to develop the estimates as well as the empirical findings by regions. The results, which are too extensive to report in detail here, suggest that the increase in both earnings and value of assets in all regions has been striking. But, large regional differences do exist.

A summary of the estimated residual earnings and real capital gains as a percentage of asset values is presented in table 2. We averaged returns by decades to minimize the effects of annual fluctuations. These findings suggest that the 10 regions have not shared equally in the economic growth of agriculture.

To apply Melichar's test to the regional data, we used regression analysis to estimate continuous growth rates in residual earnings and production asset values (table 3, columns 1 and 2). The growth rates for the two are comparable in all regions except the Lake States and the Northern Plains. If residual earnings and asset values have the same growth rates, their ratio should show no trend. The trend coefficients for these ratios are presented in column 3 of table 3. Only the two regions noted had trend coefficients significantly different from zero. Thus, for the 1950-78 period, the conclusion that earnings do support values is generally supported for the regional disaggregation. When we conducted a similar test by decades, the results were less conclusive. The hypothesis was supported by only three regions in the fifties, by six in the sixties, and by eight in the seventies. As might be expected, the results obtained depend somewhat on the time span chosen. Thus, the results are uneven, and we cannot say they provide conclusive support for the constant-growth earnings model.

Could it be said that productive assets were undervalued or overvalued in relation to earnings among regions? One of the interesting conclusions to be drawn from the literature is that after obtaining factor shares, researchers remained uncertain of how those shares should be used to determine the value of land. Thus, in the study cited above, Johnson (*11*) stated: "It is, of course, impossible to say whether the level of land values of late 1946 is generally too high." The answer to the valuation question ultimately depends on the model selected to transform earnings into values.[3]

Analyses based on the traditional valuation model, $V_e = R_1/d$, would lead to the conclusion that funds invested in agriculture were not returning their opportunity cost. When real capital gains are added to annual asset earnings, the summed return becomes quite competitive with earnings in alternative uses. This latter interpretation requires the acceptance of the equivalence, in some sense, of the real capital gain and the annual income flow. Interpretations based on the constant-growth earnings model proposed by Melichar did come closer to suggesting that returns earned by assets do justify their value in most farm regions.

In summary, even if the data base and aggregation problems could be resolved, the inherent value of research designed to value land through imputed returns will not be realized until more comprehensive theoretical models are available to translate

[2] References and a more detailed analysis of these imputation procedures are contained in our literature review (*6*, pp. 78-89).

[3] Another problem which plagues attempts to base the value of land on the imputed residual is created by the aggregate nature of the data. Returns are much higher on Class I farms. And, under a "price-leadership" model, the value of land in its most profitable use should set the asking price for all land. See our literature review (*6*, pp. 85-86).

Table 2—Average residual earnings of assets and average real capital gains as a percentage of asset value, by farm production region

Region	1950-59		1960-69		1970-78	
	Residual earnings	Real capital gains	Residual earnings	Real capital gains	Residual earnings	Real capital gains
	Percent					
Northeast	4.0	2.0	4.6	3.4	4.1	7.8
Appalachian	4.8	2.1	4.4	2.8	5.0	7.0
Southeast	7.5	4.3	6.7	3.7	6.6	6.2
Lake States	.5	1.7	3.1	1.4	5.9	8.9
Corn Belt	4.0	1.8	4.2	1.8	5.5	9.8
Delta States	6.4	3.4	6.2	5.0	7.0	3.8
Northern Plains	2.6	1.3	4.2	1.7	6.1	7.5
Southern Plains	4.0	2.8	3.6	3.2	3.4	3.4
Mountain	4.5	1.9	3.9	3.0	4.9	5.7
Pacific	6.7	3.7	5.1	2.0	8.4	2.5
48 States	4.2	2.3	4.4	2.3	5.5	6.6

Source: (*5*, table 4).

Table 3—Continuous growth rates in residual earnings and asset values for 10 farm production regions, 1950-78

Region	Percentage growth		Trend coefficient for (1)/(2) (3)
	Growth in residual earnings (1)	Growth in productive asset values (2)	
	------*Percent*------		
Northeast	4.8	5.0	−0.0021
Lake States[1]	11.3	5.3	[2].0600
Corn Belt	6.8	5.7	.0108
Northern Plains	8.8	5.9	[2].0293
Appalachian	5.5	5.6	−.0014
Southeast	5.7	6.6	−.0088
Delta States	6.7	6.7	.0007
Southern Plains	4.9	6.2	−.0128
Mountain States	6.0	6.1	−.0010
Pacific States	5.7	4.9	.0080
48 States	6.7	5.3	.0088

[1]Series includes missing values due to negative returns in some years.
[2]Significant at the 90-percent level.

Source: (*21*, tables 19 and 20).

earnings into value. We also drew a similar conclusion in our study of the econometric models of the land market.

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Soil Conservation Policies, Institutions, and Incentives

Harold G. Halcrow, Earl O. Heady, and Melvin L. Cotner (eds.). Ankeny, Iowa: Soil Conservation Society of America, 1982, 330 pp., $6.00.

Review by Craig Osteen*

This well-written and informative collection of papers and discussions accurately represents the current literature on the economics and policy of soil and water conservation—both its strengths and weaknesses. The editors group the papers under five topics: (1) history of soil conservation, (2) the soil conservation policy process of the Resource Conservation Act of 1977 (RCA), (3) attitudes and behavior of farmowners and operators, (4) socially preferred tradeoffs in soil conservation, and (5) alternative strategies of achieving soil conservation. In my opinion, the book really consists of two sections. The first addresses policy and institutions and includes topics 1, 2, 5, and Sylvan Wittwer's paper in topic 4. The second considers microeconomics and includes the remaining papers in topics 3 and 4. Each section embodies a different approach to the problems of soil conservation.

Wayne Rasmussen introduces the theme for this book by asking "why erosion remains a severe problem after 45 years of cooperative efforts by farmers and the Federal Government to solve it." The articles addressing soil conservation policy and institutions discuss past and current erosion problems and policies, the structure of soil conservation institutions, and the political pressures shaping these institutions and policies. These papers document the events leading to RCA, the process of implementing RCA, and the implications of RCA for soil conservation institutions—an interesting discussion of policy formation. During the seventies, soil conservation experts claimed that erosion with its impacts on future productivity, sediment damages, and water quality increased, whereas budget experts criticized soil conservation programs for ineffectiveness. One response to these concerns was RCA, which defined a process for assessing the Nation's soil and water resources, for evaluating current programs, and for planning future policies. Several authors discuss factors affecting soil conservation, market imperfections, policy options, and the potential impacts of new agricultural technologies on conservation problems and policies.

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I find David Allee's and Christopher Lehman's discussions of the coordinating committee assembled to evaluate existing programs and future policy options for RCA to be a fascinating glimpse into interagency politics. These authors view the process as a massive undertaking overwhelmed by data analysis and political infighting. They believe that the evaluation of existing programs was not successful and that policy options were not thoroughly examined. Lehman and Allee allege that the coordinating committee analyzed too many issues and spent too much time analyzing data; the participants should have concentrated on fewer, more important questions.

The first section's most important contribution is showing that, although the General Accounting Office and others criticize the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) for not concentrating technical and financial assistance in areas with severe erosion problems, resource allocations are a result of the political coalition supporting the program's survival. This coalition favors voluntary, locally controlled cost-sharing, and technical assistance programs. Attempts to reallocate funds to concentrate programs in areas with severe erosion problems or to develop regulatory programs would require greater centralization in Washington and could damage both the coalition and the programs.

Sandra Batie and Lawrence Libby make another important contribution by showing that RCA, as well as the nonpoint pollution control program, has broadened soil conservation policy and its constituency. They believe that soil conservation institutions will continue to emphasize traditional concerns of protecting soil fertility and flood control, but will expand their concerns to water quality and other environmental objectives. Libby believes the constituency for soil conservation may expand from farmowners and operators, changing the membership of Soil Conservation Districts and future policies.

The papers addressing the microeconomics of soil conservation emphasize the application of data analysis, economic modeling, and the variety of con-

ceptual approaches and viewpoints taken by economic researchers. I generally found these papers less current and interesting than most on policies and institutions.

William Miller and Earl Heady show the dominance of linear programing in addressing farm planning and soil conservation issues. Miller reviews studies of short-term tradeoffs between soil conservation and farm income and long-term benefits of soil conservation. He states that many conservation practices reduce current income, that discounting makes future benefits insignificant, and that new technology reduces the impact of declining productivity. Miller indicates that conservation practices need to be tailored to specific farm conditions, and he proposes including economic modeling in SCS farm planning to help farmers explore all financial aspects when they choose practices. Heady uses the Iowa State model to show that the Nation could reduce erosion in the short run with little sacrifice by emphasizing conservation tillage and contour plowing where feasible. He states that uniform limitations to soil loss across heterogenous soils are neither politically acceptable nor economically sensible; the urgency of the practices depends upon the depth and erodibility of the soils. Heady also states that there would be a different mix of practices for maintaining productivity or controlling water pollution.

Napier and Foster survey the literature of farmer attitudes and behavior toward soil conservation. They find farmers to be interested in short-term gain, aware that erosion is a problem but unaware how severe erosion is on their own land. They state that farmers favor voluntary cost-sharing and technical assistance under local control with State or Federal funding. Schertz and Wunderlich examine the U.S. Department of Agriculture's (USDA) landownership survey and the work of other USDA researchers. They find that the data do not support a relationship between selected characteristics of owners and conservation, and state that more concentrated landownership may encourage more conservation.

Eleveld and Halcrow use the mathematics of constrained optimization to characterize the determination of the socially optimal level of soil conservation. They show that differences in social and private time preferences; imperfect information; and offsite damages from sediment, pesticides, and soil nutrients could cause differences between socially and privately optimal amounts of soil conservation. They recommend development of more soil conserving technology, taxes on farming practices which do not maximize net social income, cost-sharing payments as incentives, and greater precision and discrimination in applying soil conservation policy.

Daniel Bromley addresses property arrangements surrounding soil erosion. Bromley enumerates the externalities of erosion as offsite sediment damages, the differences between social and private time preferences concerning future production losses, and the use of nonrenewable resources in fertilizers to replace lost soil nutrients. He states that the interest of landowners in soil management conflicts with the interests of others for whom the prevailing structure provides no protection. Although Bromley believes attempts to change the existing structure would raise important economic and political questions, he does not predict the outcome.

Neither section addresses how the Soil Conservation District, the State soil conservation agency, and the district soil conservationists that are key agents in soil conservation policy should change their decisions nor does either suggest economic methods to help these agents. Miller and Heady come the closest. Most of the other authors concentrate on decisions at the national or farm level, not at the State or local level. I find little discussion on how State and local officials can allocate limited cost-sharing funds and technical assistance among practices, farms, or areas with different erosion problems. I see this issue as the key topic for future economic research and policy analysis.

Several authors mention the interaction between soil management and water quality, potential conflicts and complements between soil conservation and water quality programs, and the emergence of environmental objectives in soil conservation programs. Unfortunately, they do not explore these timely issues further.

The book's strength lies in its showing the agreements and conflicts in the authors' viewpoints. It illustrates much of the recent work on the economics and policy of soil conservation and shows where more work is needed. I recommend it to anyone who wants to learn more about this subject.

Readings in Farming Systems Research and Development

W. W. Shaner, P. F. Philipp, and W. R. Schmehl (editors). Boulder, Colo.: Westview Press, 1982, 175 pp., $19.

Farming Systems Research and Development, Guidelines for Developing Countries

W. W. Shaner, P. F. Philipp, and W. R. Schmehl (editors). Boulder, Colo.: Westview Press, 1982, 414 pp., $25.

Reviews by Michael A. Cullen*

The term "Farming Systems Research" (FSR) has been in use for some time, and through the continual efforts of its practitioners, its acceptance as a method for understanding farmers and farming has grown in recent years. It requires that researchers investigate the interdependence of components of a farm unit controlled by the farm household as these components interact with physical, biological, social, and economic factors. For example, if a newly introduced crop variety that requires a change in labor practices is to be successfully adopted, then a full understanding of the patterns and customs surrounding labor allocation and requirements in the local economy needs to be established. A thorough knowledge of the social structure and of the potential for change is, therefore, essential.

FSR's growing acceptance by agricultural scientists working in various parts of the world—principally agronomists, soil scientists, and economists—has come from a perception that the standard approach to agricultural research and extension, whereby each scientist looks at an isolated set of constraints to development (for example, soil fertility or plant breeding), has been largely unsuccessful. This perception has convinced many researchers that they have considered farming practices and technological innovations in too narrow a context. Scientists have thereby neglected the larger context, the farm as a system operating within other social and environmental systems. Thus, researchers working in different parts of the world have independently come to realize that the need for a new approach to the study of farming exists. Although these researchers have come to the same conclusion, they have each fashioned their own approaches from their experiences or those of their research institutions. Consequently, no single approach has emerged; rather it appears that the term FSR is a large, general rubric under which almost anything can be included.

The book, *Readings in Farming Systems Research and Development* (FSR&D), demonstrates the variation in the concepts and interpretations of FSR&D. A diversity of opinion exists on the goals of FSR, on which farmers should be studied, on who will collaborate to do the research, and on how it should be connected with existing research institutions.

In the paper entitled "A General Overview of FSR," David Norman and Elon Gilbert state: "The goal of FSR is to improve the well-being of individual farm families by increasing the overall productivity of the farming system . . . ." Such a broadly stated goal would seem to encompass almost anything in the farming system and illustrates a holistic approach.[1] By contrast, in the paper entitled "Aiming Agricultural Research at the Needs of Farmers," Don Winkelmann and Edgardo Moscardi limit the goal of FSR considerably by stating: "research . . . results are intended for near or intermediate term application, e.g. fertilizer research or plant breeding." Such a narrow goal would exclude considering social and economic elements not directly related to the specialized innovations they intend to research and introduce. This approach emanates from work done at the International Maize and Wheat Improvement Center (CIMMYT).

In a paper entitled "Motivating Small Farmers to Accept Change," Peter Hildebrand discusses the FSR orientation used at the Agricultural Science and Technology Institute (ICTA), which is geared to small farmers who are defined as "all farmers regardless of the size of their holdings, who are not primarily commercial farmers . . . [who] use predominantly traditional technology." Moreover, the technology which is to be introduced must be ready for immediate use under present conditions and it must be acceptable to target farmers. Hildebrand emphasizes change that is suitable to farmers under current conditions, but he does not restrict the kind of innovations or the sort of farm on which he chooses to work. Innovations could be in plant variety, changes in input use, or labor-saving implements or techniques.

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[1] The holistic approach views the whole farm as a system and emphasizes the interdependence among its components.

Hubert Zandstra, in his paper "A Cropping Systems Research Methodology for Agricultural Development Projects," simply states: "The goal of agricultural research is to formulate improved production recommendations that are acceptable to farmers." This too is general, but he qualifies the approach by formulating a functional relationship between crop production, management capabilities, and the environment. Recommendations must be consonant with the managerial capabilities of the system in question and be conditioned by the environment in which the system is found. Research must be related to the production environment. Zandstra's methodology results from work done at the International Rice Research Institute (IRRI).

Other discrepancies exist between the methods chosen by these researchers. Norman and Gilbert ask an important question: "How holistic should FSR be?" This query reaches the heart of the matter because it asks what do we need to know and who will discover it? Though all the authors agree on collaborative, multidisciplinary research, they disagree over which fields should be represented. While pushing for a practical holism, Norman, Gilbert, and Hildebrand express the need to involve anthropologists and sociologists with economists who are working in consort with the biological scientists. Infusing the research with a wide spectrum of orientations is crucial to these authors, for it provides the insight necessary to understand the structures and constraints of the farming system. Winkelmann, Moscardi, and Zandstra, on the other hand, argue for including only agricultural economists in the work with biological scientists, implying that the economist's perspective sufficiently complements the work of the biological scientist who looks at only a narrow range of physical relationships. By contrast, the discussions of onfarm research and testing show the greatest similarities among these papers. This is so because the survey and field trial measurement techniques, through wide application and refinement, have evolved more fully than any other facets of FSR. They have been in constant use and are, therefore, diffused throughout the research community.

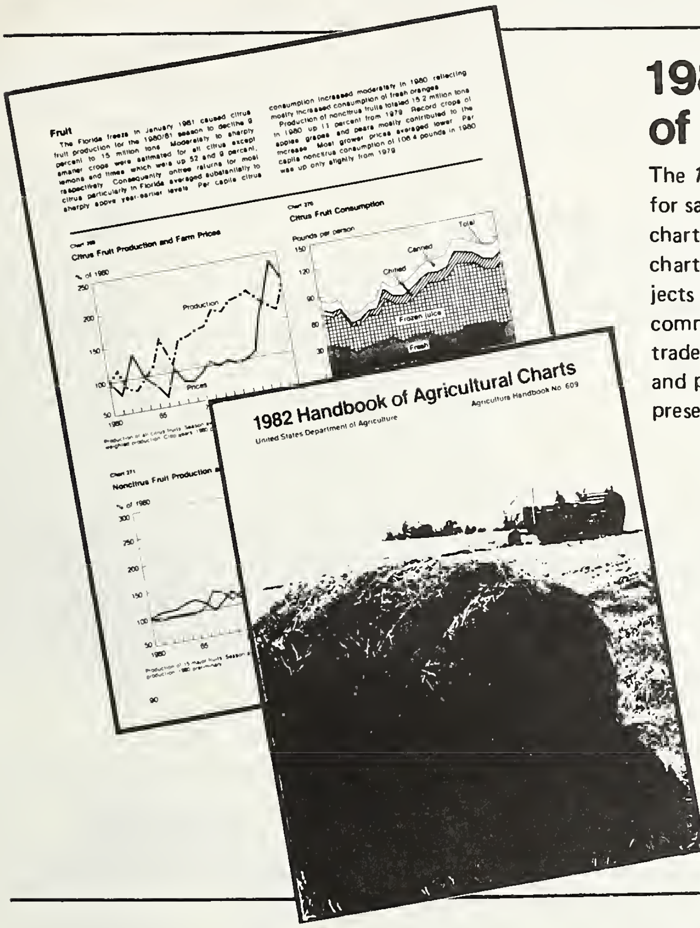
Finally, each paper mentions the links to the existing research institutions, which are mostly nationally funded and maintained, and each paper speaks to the problems these institutions represent. By expatiating on the need for FSR, the authors imply that these institutions have failed to develop worthwhile innovations because they have relied too heavily on the conventional research approach. They have remained too limited in their conception of agricultural production problems and so have been prevented from producing lasting, practical results. The onfarm approach propounded in this book challenges their accepted widsom and contradicts their research orientation, yet all of the authors advocate including them in the process of introducing FSR. They cannot be excluded from the research process because they are already in place and represent substantial investment, and more important, they contain the only pool of trained researchers available in many developing countries. In fact, they may represent the only hope of carrying out research in many of these countries. Therefore, if FSR is to infuse the research approach, these available researchers must be trained in its techniques and made aware of its potential for solving the agricultural production problems besetting the developing countries.

Even though these researchers conceive of the problems differently and are asking questions referring to specific locations and conditions, it is encouraging that they are going beyond the limits of the conventional research approach. The reorientation of agricultural research toward a more holistic outlook can help shed light on the problems of farming for most of the farmers in the developing world.

The companion volume, *Farming Systems Research and Development, Guidelines for Developing Countries*, is a well thought-out, practical guide to understanding FSR&D, and it instructs the reader on its underlying concepts and discusses some of the methods already developed. Although there is a diversity of interpretation on the goals involved in FSR&D, this volume succinctly describes its onfarm orientation and the methodology that has been devised for its execution. It describes thoroughly how to investigate individual conditions of small farmers by coordinating interdisciplinary research that is "oriented to problem solving, comprehensive, iterative, dynamic, and responsible to society." This is a volume intended for foreign nationals, trained primarily in one of the agricultural sciences, who can benefit from the broad perspective of FSR, which will allow them to approach the problems of agricultural research in a more insightful and produc-

tive manner. It emphasizes that physical systems cannot be considered apart from social and economic ones and that this approach can provide more practical and workable results from research than has thus far been the case.

As a new point of departure, this volume is quite practical. It is an excellent rendering of the concepts elucidated in the *Readings* volume, for it puts into clear language the conceptual framework, research area selection, problem identification, onfarm research planning and analysis, extension of results, and methods of training for these activities. The tables, charts, and diagrams are well designed and contain a plethora of information, succinctly illustrating many of the points made in the text. The appendix also details procedures described in the text and instructs the reader in how to follow them. For anyone who wants a practical guide to carrying out FSR&D, or simply a nuts and bolts description, this is a fine volume.



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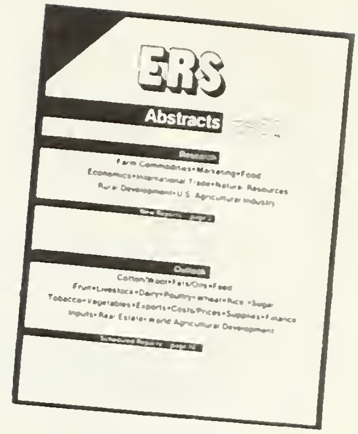

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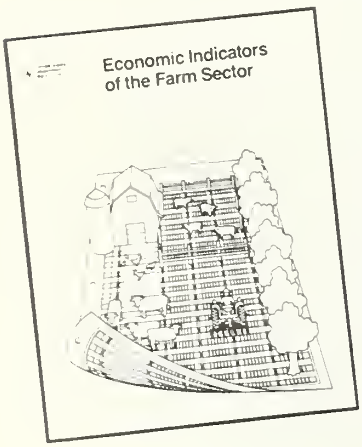

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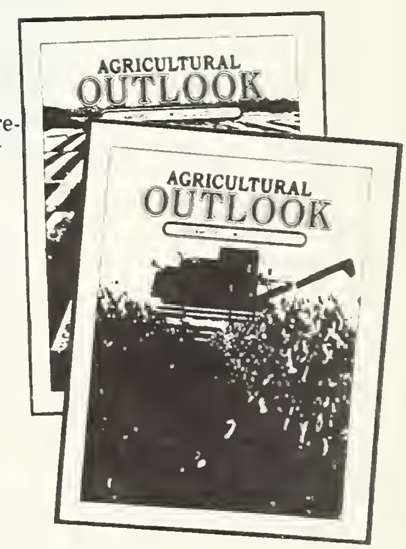

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